Environment Canada Environnement Canada

Environmental Quality in the Atlantic Region - 1985

Summary Report

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Canada

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This is a summary of the report entitled:
"Environmental Quality in the Atlantic Region 1985"

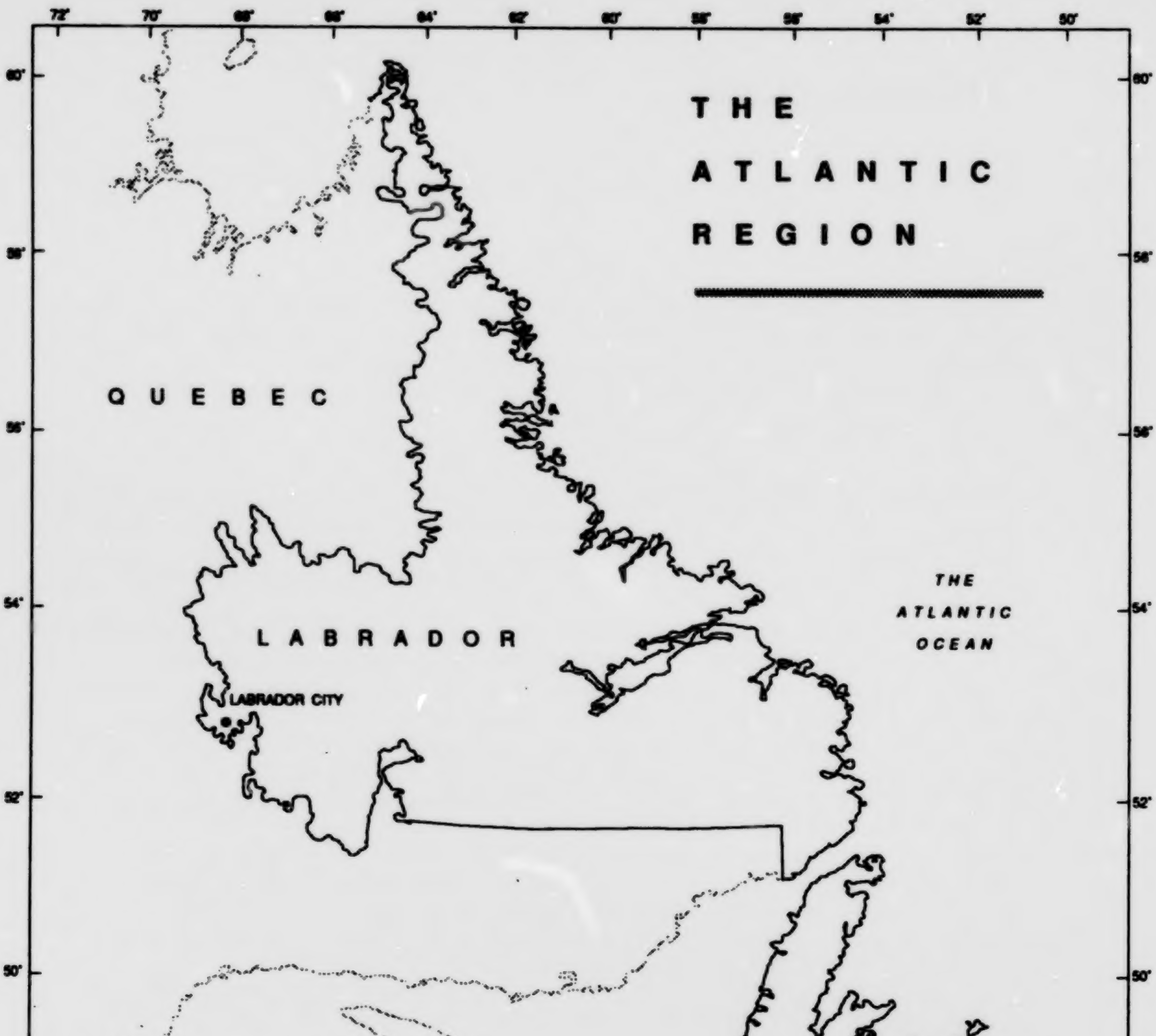
Également disponible en français sous le titre:
"La qualité de l'environnement dans la région de l'Atlantique 1985"
Résumé

Introduction

"Only with increased understanding can sources of contamination be controlled, to eventually reverse the (negative) trends that are becoming apparent."......
....Environmental Quality in the Atlantic Region 1985

Environment Canada is proud to publish the report and this summary as part of its network of environmental reporting which began in May of 1986 with the publication of Canada's first-ever national State of the Environment Report.
Environmental Quality in the Atlantic Region 1985 examines the Atlantic region's ecosystem, just as the national State of the Environment Report did for all Canada. This report presents more detailed regional data than the national report could hope to accomplish. It is the second report of its kind developed by regional Environment Canada staff. This summary provides highlights of the main report.

The Atlantic Region's first environmental status report was issued in 1980, and its publication led to some fascinating comparative analyses and identification of regional environmental trends. Provincial and local officials involved with environmental monitoring and management have proven invaluable sources of input for both reports.


THE ATLANTIC REGION
QUEBEC
LABRADOR
LABRADOR CITY
THE ATLANTIC OCEAN
GULF OF ST LAWRENCE
NEWFOUNDLAND
EXPLOITS R.
CORNER BROOK
GANDER
ST JOHN'S
P.E.I.
CHARLOTTETOWN
NEW BRUNSWICK
RESTIGOUCHE R.
BATHURST
MIRAMICHI R.
MONCTON
SAINT JOHN R.
SAINT JOHN
BAY OF FUNDY
MAINE
NOVA SCOTIA
SHUBENACADIE R.
HALIFAX
SYDNEY
YARMOUTH
SABLE I.
0
100
200
KM
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70°
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50°
48°
46°
44°

Summary Highlights and Trends

--Retail gasoline outlets in Atlantic Canada used to be the worst violators of the lead-free gasoline regulations, which specify the maximum allowable concentrations of lead in "lead-free" gas. In 1978, the violation rate in Atlantic Canada was 5.9 per cent compared to 4.2 per cent nationally. However, the figures changed so dramatically that, by 1984, the national violation rate was 3.0 per cent, but in Atlantic Canada, it was 2.2 per cent. (See pp. 22 - 25 of full technical report)

--Nationally, the overall annual average of total airborne suspended particular matter (TSP) decreased approximately 20 per cent between 1974 and 1981. In the Atlantic region, TSP levels generally declined between 1974 and 1983. (pp. 3 - 8)

--Total emissions from the two chlor-alkali plants in the Atlantic region (one each in New Brunswick and Nova Scotia) declined by 75 per cent between 1978 and 1984, largely because of compliance with federal regulations. (pp. 25 - 27)

--Nitrogen deposition, which comes largely from the transportation sector, has doubled in Atlantic Canada since 1954, and may increase further because, without further control measures, emissions are expected to increase by 30 per cent by the turn of the century. (p. 30)

--The pH of precipitation samples collected in Atlantic Canada ranges from 3.5 to 6.0, with the majority between 4.2 and 4.8. In comparison, the average pH of rain and snow collected in Kentville, Nova Scotia between 1952 and 1954 was 5.7. The mean pH of 16 lakes in New Brunswick and Nova Scotia decreased from 6.3 in the 1950s to 5.7 in 1979. A one-unit drop in pH level is actually a ten-fold increase in acidity. (pp. 29 - 35)

--Soil erosion rates in New Brunswick have increased by over five times since 1945. (pp. 45 - 48)

--Between 1972 and 1982, point source pollution in the Saint John River Basin was reduced by 88 per cent in terms of biological oxygen demand (BOD) loading, and by 82 per cent in terms of suspended solids (SS) discharged. (Pg. 49) For the pulp and paper industry as a whole in the Atlantic region, the discharges of both have been steadily declining. Between 1969 and 1984, BOD was reduced by approximately 60 per cent and SS by 51 per cent. (pp. 59-61)

--New Brunswick reported 71 cases of leaking gas storage tanks and pipelines in 1983, a ten-fold increase in the past decade. (p. 57)

--From 1974 to 1984, there was a 70 - 90 per cent reduction in phosphorous discharges from the Electric Reduction Company (ERCO) in Long Harbour, Newfoundland. Between 1975 and 1980, ERCO was successful in bringing its effluent from continuously toxic to almost always non-toxic as a result of improved treatment facilities. (p. 69)

--There is an increasing emphasis on coal utilization in Atlantic Canada -- 74 per cent more coal was consumed in 1982 than in 1978. (p. 69)

--A new effluent treatment system at the Belledune lead smelter has reduced cadmium loadings by 97 per cent since 1980. (p. 98)

--Only 5.0 per cent of liquid industrial wastes are recycled in the Atlantic region compared to 18 per cent in Ontario. Another 15 per cent of the total amount of hazardous wastes generated in the region could be recycled, and an additional 45 per cent could be disposed of using alternative practices. (p. 117)

--In 1984, 433 oil and chemical spills were reported to the Environmental Protection Service (EPS) in the Atlantic region, up from 348 in 1981. While the total number of reported spills increased, the number of spills greater than 2,275 litres (called "significant events") decreased in the Atlantic region during the 1980s. (See Table 26, p. 124)

Air Quality

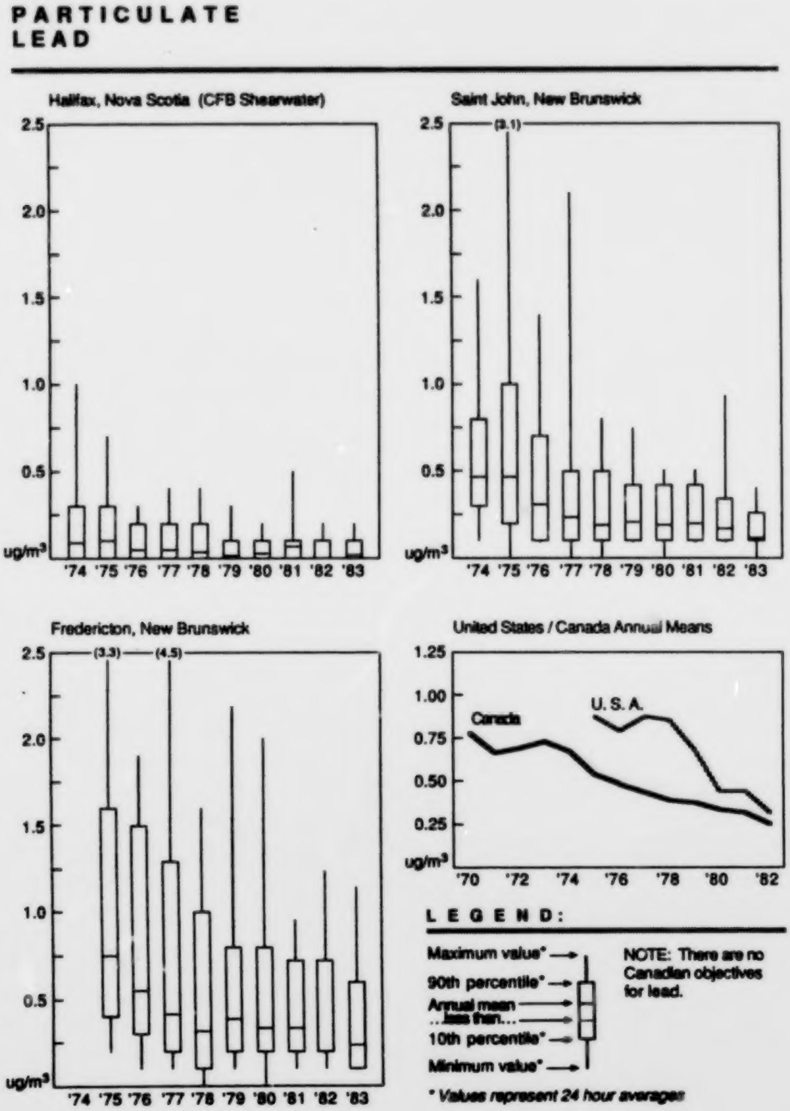
The air in Atlantic Canada is generally cleaner now than it was five years ago, as a result of a combination of efforts by local industry and government policy-makers, but there are still problem areas. There are fewer particles in the urban air -- levels of total suspended particulates (TSP) in Halifax, Charlottetown, St. John's and Fredericton are consistently below both the Canadian and American national averages and are within the "desirable" objectives range.

Federal regulations lowering the amount of lead in gasoline have already contributed to a steady decline in the levels of lead in the air throughout the region because the largest single source of atmospheric lead emissions (greater than 70 per cent) is the automobile. Lead levels are expected to decline even further after tougher, new federal guidelines go into effect next year. Retail gasoline outlets in Atlantic Canada, once the worst violators of lead-free gasoline regulations, improved so much since 1979 that the region is now below the national average for violations.

Canada banned aerosol sprays containing fluorocarbons in 1980 because they were damaging the atmospheric ozone layer that protects the Earth from ultraviolet rays. While stratospheric ozone is desirable, recent research shows ozone is now being produced at ground level by a photochemical reaction of some gases and sunlight. Ground-level ozone is considered a pollutant which may be dangerous to human health, and the majority of reports from Atlantic monitoring stations show readings above the maximum acceptable objective.

Furthermore, the level of polycyclic aromatic hydrocarbons (PAHs) will likely increase in Atlantic Canada over the next few years, as the conversion of power plants from oil to coal continues, and as residential fuel wood burning increases. Wood stoves and fireplaces may be important lifestyle appliances, but wood combustion produces atmospheric PAH and suspended particles.

A much more localized problem continues in Newfoundland. In spite of a multi-million dollar clean up, there is still concern about high levels of asbestos in the air at the asbestos mining sites at Baie Verte. It appears that the levels can be traced to asbestos dust that was released before the clean up, and a program of sealing off the surrounding sources is expected to improve conditions.



Ambient air monitoring trends for lead (Pb) in Atlantic region cities (1974-1983)[2]

Water Quality

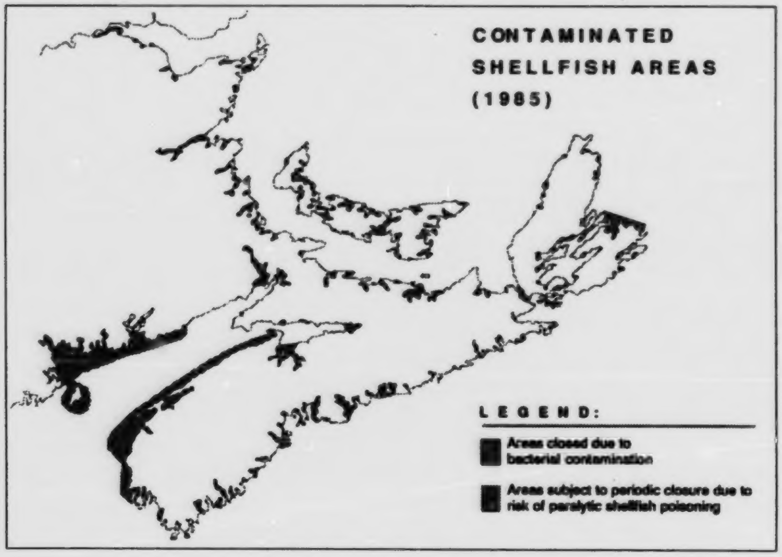
Inland waters support fish and wildlife and are essential for domestic use, agricultural/industrial supply, and for recreation and aesthetic enjoyment. Most of the public drinking water supplies in the region meet the acceptable limits of the drinking water guidelines most of the time, but some fail to do so on an unacceptably regular basis. There is generally adequate freshwater for irrigation and industrial supply.

Chemical contamination of domestic water supplies is starting to have economic implications for residents in the Atlantic region, as more taxpayers are forced to abandon existing wells or water systems and develop new ones. Although contamination is becoming increasingly evident in groundwater supplies, it still affects only a small proportion of supplies.

Sport and commercial fishing are important sources of recreation and revenue on the east coast. Although salmon and trout populations appear to have been declining over the last 25 years, the current levels of contamination in their tissues rarely exceeds the limits acceptable for human consumption. In the last 10 years, improvements have been made to severely oxygen-depleted rivers, particularly those affected by pulp mills and municipal sewage. The improved oxygen regime on the St. Croix River on the New Brunswick-Maine border, for example, is now such that the river is once again capable of supporting salmon runs.

Coastal waters appear hardest-hit by modern life and by nature. Closures of shellfish growing areas are on the increase due to industrial and municipal discharges and naturally-occurring menaces such as red tide. Mining effluents, municipal discharges, siltation, agricultural runoff, obstructions to fish passage and acid rain have all affected fish habitat.

In 1983, the number of shellfish growing area closures reached 262, up 25 from 1979. Twenty-two per cent of the soft-shell clam flats in the Scotia-Fundy area are closed. The closures are a result of an increase in fecal contamination and better surveillance by federal authorities. That surveillance has helped ensure that there were no major outbreaks of intestinal diseases attributed to shellfish harvested from approved growing areas since 1972.


CONTAMINATED
SHELLFISH AREAS
(1985)
LEGEND:
■ Areas closed due to bacterial contamination
■ Areas subject to periodic closure due to risk of paralytic shellfish poisoning

Contaminated shellfish areas in the Maritimes (1985)[120]

The harvest of oysters, clams and mussels still contributes $5 million to the Atlantic economy annually, but closures of growing areas contributed to unemployment, a decline in tourism and higher prices to shellfish consumers.

The adverse economic impact of coastal pollution on the local shellfish industry is best illustrated at Caraquet Bay in northeastern New Brunswick. Caraquet Bay produces 70 per cent of New Brunswick's catch of oysters, even though at the moment 2,400 hectares of its waters are closed to the harvest of shellfish due to fecal contamination. Currently, commercial shellfish harvesting in the Bay is estimated at $500,000. If the pollution problems were eliminated, the annual production of oysters could increase to $2 million.

This kind of improvement is clearly possible. For example, a new effluent treatment system at the Belledune lead smelter in Northern New Brunswick has reduced cadmium loadings by 97 per cent since 1980, when Belledune Harbour lobster fishing was closed. The resulting decline in cadmium levels in the lobsters allowed the fishery to reopen in 1985, under controlled marketing conditions.

Off-shore waters appear to be in good shape, registering levels of contamination consistently below the level of observable harm. DDT pesticide residues in the blubber of grey seals on Sable Island in 1982 were lower than comparable samples taken in 1974. This is the first clear indication that DDT group residues are reflecting the ban on DDT of the early 1970s. However, litter made of substances that resist biodegradation, such as plastics, is showing up more often, interfering with the aesthetic environment and devaluing the region's tourism potential.

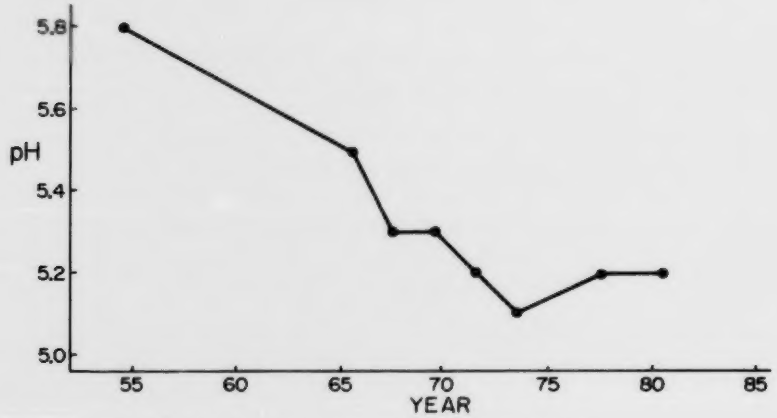
Acid Rain

Acid rain is formed in the atmosphere from sulphur dioxide (SO_2) and oxides of nitrogen (NO_x), which result from the combustion of fossil fuels. Seventy-five to 80 per cent of the sulphur dioxide deposited in Atlantic Canada is generated in central Canada and the northern United States. The major source of locally-generated SO_2 is thermal generating stations.

The effects of acid rain can be discerned in the changing pH levels of lakes, rivers and precipitation. The term "pH" is a measurement of acidity on a scale from 1 to 14, with 7 being neutral. Numbers below 7 are acidic, and a one-unit drop (for example, from 6 to 5) represents a 10-fold increase in acidity.

The pH of snow, rain and other precipitation samples collected in Atlantic Canada currently ranges from 3.5 to 6.0, with the majority between 4.2 and 4.8. In comparison, the average pH of rain and snow collected in Kentville, N.S., between 1952 and 1954 was 5.7. The mean pH of 16 lakes in New Brunswick and Nova Scotia decreased from 6.3 in the 1950s to 5.7 in 1979. Fish appear to start suffering damage at pH levels below 6.0; below pH 4.5, most fish populations are wiped out. Increased acidity can alter the plant and animal communities which serve as food for fish and their prey. Acidic water also mobilizes or dissolves metals from sediments into the water column, thus exposing fish to greater concentrations of toxic metals. It is often difficult to distinguish the effect of acid rain on aquatic life from stresses such as over-fishing, physical alteration of habitat and other contaminants.

Acid rain damages the man-made environment, too: for example, it can accelerate erosion of buildings, paint and cars. The cost of these damages is estimated to exceed $285 million a year in Canada, and $5 billion a year in North America. But its most dangerous aspect is its reach. Few other types of pollution are capable of rendering a remote, apparently pristine, body of water devoid of aquatic life.



pH decline in the Medway River, Nova Scotia (1955-1980)[46]

Forestry and Agriculture

The composition of forests in the Atlantic region has significantly changed since settlement began. Extensive clearcutting, forest fires and disease have resulted in a predominance of balsam fir and spruce, both highly susceptible to spruce budworm attack. The most recent annual budworm infestations have essentially destroyed the fir and spruce forest of the Cape Breton Highlands and have killed conifers in New Brunswick, mainland Nova Scotia and Newfoundland. Clearcutting and the widespread replanting of single species of trees are expected to increase in the future, and this will further increase the susceptibility of forest stands to disease and infestation.

There are improvements, however, in what happens once the trees are out of the woods. Pulp and paper mills have considerably reduced the effluent discharges in recent years. For example, the amount of potentially toxic oxygen-demanding wastes (BOD) discharged in the Atlantic region is down 60 per cent, while discharges of suspended solids decreased 51 per cent. A five-year federal-provincial modernization program was initiated at 13 of the 20 mills in the region in 1980-81. By 1984, nine of those plants were in compliance with the Federal Pulp and Paper Effluent Regulations of the Fisheries Act for suspended solids discharge, with another three near compliance. Ten plants were in compliance for BOD discharges, with another four near compliance.

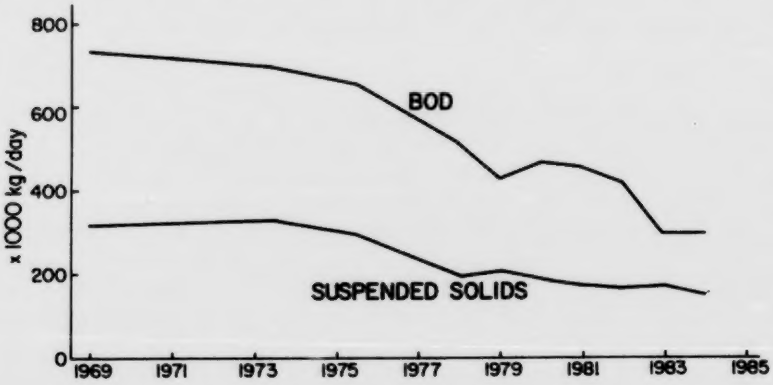


Figure 19 Trends in Atlantic region pulp and paper mill effluent discharges (1969-1984)[19]

The number of chemicals used as pesticides has steadily grown over the years. For example, as of January 1, 1985, there were 514 chemical pesticides registered for use in Canada as compared to 30 in 1940 and approximately 400 in 1979. Past environmental monitoring for pesticides in the region has focussed on forestry insecticides, and, to a lesser degree, on forestry herbicides. The fate, persistence and environmental effects of agricultural pesticides has become a recent focus of monitoring efforts, although few regional studies have been completed. Nonetheless, agricultural lands in Canada receive 15 times more insecticide than do our forests.

In Prince Edward Island and parts of New Brunswick, current farming practices are the major contributors to a siltation problem which is increasing every year. Larger field areas with fewer protective hedgerows provide less resistance to wind erosion. It is also common practice to plough in the fall, which exposes the soil to even more erosion by wind and water during the winter and spring. Soil erosion rates in New Brunswick are five times higher than they were in 1945, with farmers in the western part of the province losing between 22.5 and 45 tonnes of soil per hectare every year. The maximum tolerable level recommended by New Brunswick's Department of Agriculture is nine tonnes per hectare per year.

In the absence of green belts or other protective measures, as much as 25 to 40 per cent of the soil that runs off a field reaches a water body, taking its metals, minerals and contaminants with it. Significant efforts have been made recently to reverse these damaging trends. Widespread adoption of environmental guidelines for the construction of forest access roads and vegetated buffer strips along streams throughout the region may be reducing some of the problems of siltation. Salmon and trout are probably the greatest victims of siltation. In addition to releasing its contaminants into the water, silt covers clean gravel in which salmon and trout lay their eggs.

Hazardous Waste and Toxic Chemicals

The management and disposal of hazardous wastes is a priority concern everywhere in Canada. In the Atlantic region, media coverage of such incidents as the PCB contamination at an Amherst, N.S. landfill and the excavation of discarded herbicide barrels at abandoned dumpsites in New Brunswick, has focussed public attention on this issue. In spite of all the attention, a great deal of uncertainty still surrounds the issue of hazardous waste disposal, transportation and storage.

In 1984, 433 oil and chemical spills were reported in the Atlantic region, up from 348 in 1981. While the total number of reported spills increased, the number of spills greater than 2,275 litres, called "significant events" by environment officials, decreased during the 1980s.

Atlantic Canada lags behind much of Canada in the development of sewage treatment facilities. Many smaller communities have sewage treatment systems which control the contents of wastes going into water systems, but larger, older centres, including Halifax, Dartmouth, Sydney, Edmundston and St. John's, have limited or no treatment facilities.

The presence of toxic chemicals in the fresh waters of Atlantic Canada is becoming increasingly apparent. These chemicals, both organic and inorganic, originate from natural and man-made sources within and outside the region. The concern over their presence in freshwater stems from the fact that they tend to be widely dispersed, may be highly persistent, may accumulate in biological tissues, and may cause biological changes even in trace amounts.

Groundwater contamination has only recently been recognized as a serious threat in this region, as increasing numbers of cases of contamination from bacteria, salt, nitrates, pesticides and petroleum products are found. New Brunswick reported 71 cases of leaking gas storage tanks and pipelines in 1983, a 10-fold increase in the past decade. Materials disposed of, or spilled, on or in the ground, are showing up more and more often in the groundwater of Atlantic Canada. Waste disposal sites are among the worst offenders, as few in the region are operating properly. In general, it is expected that more evidence of contamination will show up throughout the region in the coming years.

Clean ups are already underway at some waste sites. One example is the so-called "Tar Ponds" adjacent to the Sysco steel plant in Sydney, N.S. Although serious air and water pollution problems are still apparent, discharges from Sysco have been reduced in recent years due to clean-up initiatives and production slowdowns. Engineering studies on how to eliminate or treat and control further discharges from the Tar Ponds have recently been completed.

Not all contaminants originate with human activity. Arsenic is naturally occurring, and occasionally finds its way into well-water. In Halifax county, arsenic contamination of wells in several communities has been documented over the last decade. In 23 per cent of the samples analyzed, the contaminant level was five times the permissible limit. Chronic symptoms of arsenic poisoning were found in approximately 30 per cent of the consumers of water from contaminated wells in Waverley, N.S.

Some hazardous wastes can be recycled. However, only five per cent of industrial wastes are currently recycled in the region compared to 18 per cent in Ontario. Another 15 per cent of the total amount of hazardous wastes generated in the region could be recycled, and 45 per cent could be disposed of using alternative practices.

Energy and the Environment

Generating power for use in modern society creates a multitude of concerns. Coal and oil combustion may result in acid rain and local air quality problems. Hydro power can alter water quality and quantity, and fuelwood use can change the diversity of forest ecosystems and affect local air quality. Nuclear power, which became a reality in the Atlantic region in 1983 when the Point Lepreau generator began operating, creates public controversy.

Coal is used primarily in the Atlantic region for electricity generation, with smaller quantities used in the industrial and commercial sectors. Coal use is expected to continue to rise, and its use is projected to stabilize at 22 per cent of the area's energy demand by the late 1990s.

The increased use of coal could have significant environmental effects. Coal mining can lead to acid drainage near mining sites, which, in turn, leads to reduced soil and water quality and can cause fish kills. Transportation of coal releases dust particles which can contribute to local air and water pollution.

The combustion of coal, which contains sulphur, contributes significantly to the formation of acid rain. Some local coals are high in sulphur and contain significant amounts of lead, chromium, aluminum, uranium and arsenic, which can be concentrated in the ash or emitted to the air. However, new combustion technologies are being tested at Summerside, P.E.I., Pt. Tupper, N.S., and at Chatham and CFB Gagetown, N.B. These new coal burning methods (including fluidized bed combustion, coal and water slurry and limestone injection burner) should substantially reduce SO_2 and NO_x emissions from coal-fired plants.

Hydro power accounts for 79 per cent of the electricity produced in the Atlantic region. An environmental protection plan is currently being produced by Newfoundland and Labrador Hydro to plan for future power line transmission corridors. Dams and transmission lines can have a variety of effects on wildlife and habitats, not all of them negative. However, for example, hydroelectric development on the Saint John River has reduced the river's capacity to assimilate wastes, resulting in fish kills due to oxygen depletion in the head ponds.

The best way to reduce the costs of energy in both dollars and environmental damage is to conserve it. By the year 2000, it is estimated that Canadian industry will use 32 per cent less energy to produce the same type of products it turned out in 1978. Deriving energy from alternative sources such as municipal waste, biogas, liquid alcohol fuels, peat, solar energy, wind-generated electricity and geothermal energy is being investigated in the region. In addition, Atlantic Canada is home to one of only three tidal power stations in operation in the world. However, it is already apparent that while tidal power stations are "clean", they can produce flooding and create physical obstacles for fish.

In Conclusion

The report, Environmental Quality in the Atlantic Region 1985, does not include statistics that cover every aspect of the Atlantic environment. It is not designed to point an accusing finger at specific sources of pollution, or to make recommendations. However, it does give the reader a snapshot picture of the whole Atlantic ecosystem. It is the second report of its kind in the Atlantic region, and is being issued as part of the national environmental reporting network initiated by Environment Canada. We plan to produce such reports every few years. Over time, we will be able to compare our snapshots, using them to analyze trends and identify the sources of problems in the environment. For the moment, the report serves to inform the public about the state of the air, land and water of Atlantic Canada, and to give interested organizations, agencies and governments benchmarks and data which may inform their decision and policy-making.

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Environnement Canada
Environment Canada

La qualité de l'environnement dans la région de l'Atlantique - 1985

Résumé

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Canada

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Cette publication est un résumé du rapport intitulé:
“La qualité de l’environnement dans la région de l’Atlantique 1985”

This publication is also available in English under the title:
“Environmental Quality in the Atlantic Region 1985”
Summary Report

Introduction

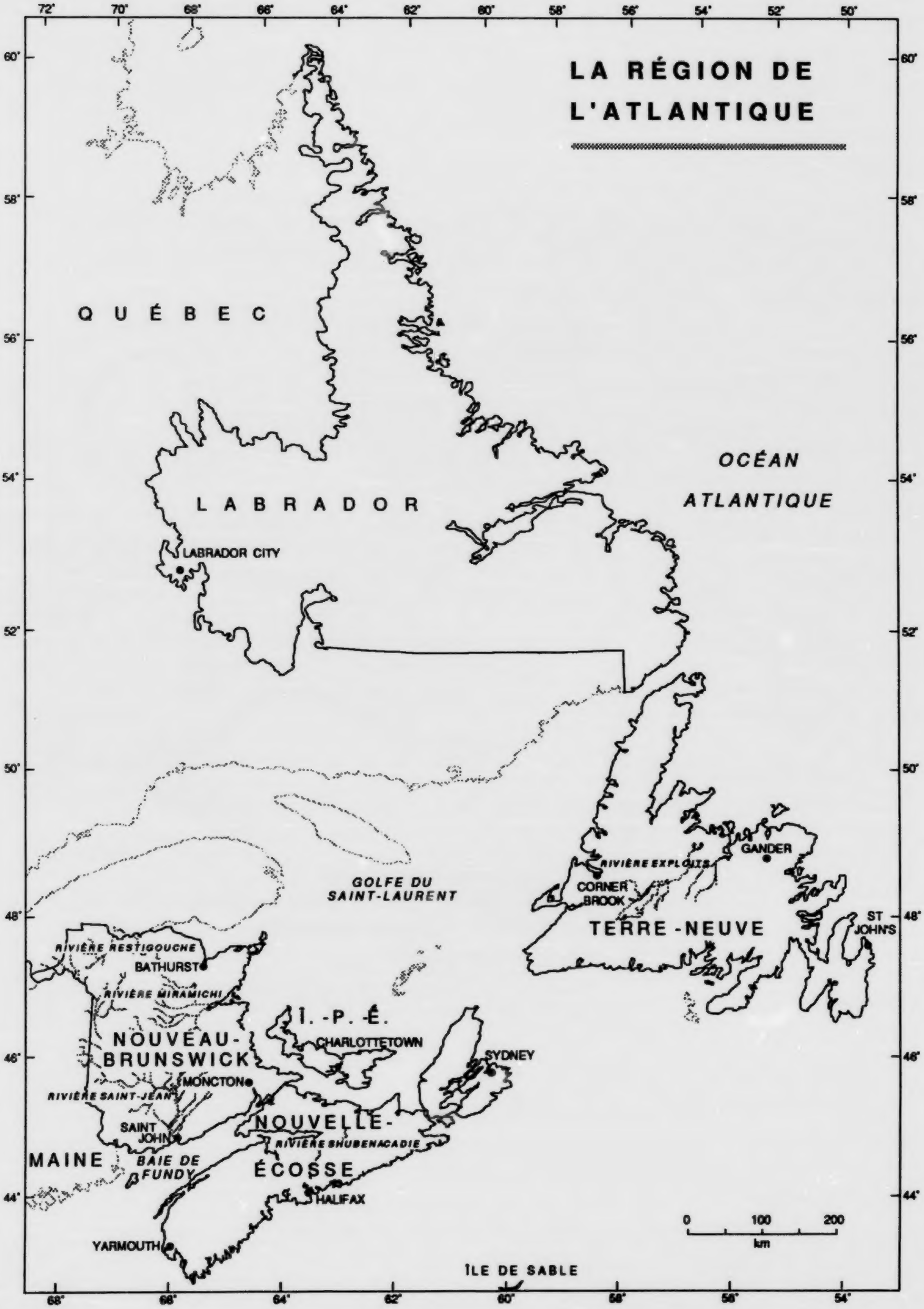
"Ce n'est qu'en comprenant mieux les sources de pollution que nous parviendrons à les contrôler et éventuellement à renverser la tendance (négative) qui se fait de plus en plus évidente."

> -- La qualité de l'environnement dans la région de l'Atlantique (1985)

Environnement Canada est fier de publier le rapport et ce résumé qui s'ajoutent à notre série de rapports sur l'environnement. Nous avons lancé cette série en mai 1986 par la publication du premier Rapport sur l'état de l'environnement au Canada.

La qualité de l'environnement dans la région de l'Atlantique (1985) traite de l'écosystème de la région de l'Atlantique au même titre que le Rapport sur l'état de l'environnement au Canada. Ce rapport renferme des éléments d'information plus pertinents à l'échelon local que le rapport national n'aurait pu espérer le faire. Il s'agit du deuxième rapport du genre préparé par le personnel régional d'Environnement Canada. Ce résumé renferme quelques points saillants du rapport principal.

Le premier rapport sur l'état de l'environnement dans la région de l'Atlantique, publié en 1980, avait permis quelques études comparatives fascinantes de même que l'identification de certaines tendances régionales en matière d'environnement. Les responsables provinciaux et locaux de la surveillance et de la gestion de l'environnement se sont avérés une source précieuse de renseignements pour la préparation de ces deux rapports.


LA RÉGION DE L'ATLANTIQUE
QUÉBEC
LABRADOR
LABRADOR CITY
OCÉAN ATLANTIQUE
GOLFE DU SAINT-LAURENT
TERRE-NEUVE
RIVIÈRE EXPLOITS
GANDER
CORNER BROOK
ST JOHN'S
RIVIÈRE RESTIGOUCHE
BATHURST
RIVIÈRE MIRAMICHI
Î.-P.-É.
CHARLOTTETOWN
NOUVEAU-BRUNSWICK
MONCTON
RIVIÈRE SAINT-JEAN
SAINT JOHN
SYDNEY
NOUVELLE-ÉCOSSE
RIVIÈRE SHUBENACADIE
MAINE
BAIE DE FUNDY
HALIFAX
YARMOUTH
ÎLE DE SABLE
0 100 200
km
72° 70° 68° 66° 64° 62° 60° 58° 56° 54° 52° 50°
60° 58° 56° 54° 52° 50° 48° 46° 44°
68° 66° 64° 62° 60° 58° 56° 54°

La région canadienne de l'Atlantique

Résumé des points saillants et tendances

-- Autrefois, les détaillants d'essence de l'Atlantique étaient ceux qui enfreignaient le plus le règlement sur l'utilisation de l'essence sans plomb, lequel spécifie la concentation maximale de plomb permise dans l'essence sans plomb. En 1978, le taux d'infraction dans cette partie du pays était de 5,9 pour 100 comparativement à 4,2 pour 100 à l'échelon national. Toutefois, la situation s'est renversée de sorte qu'en 1984, le taux d'infraction national se situait à 3,0 pour 100, alors que dans les provinces de l'Atlantique, il était de 2,2 pour 100. (Voir p. 29-33 du rapport principal)

-- La moyenne globale annuelle du total des particules en suspension dans l'air (TPS) a diminué d'environ 20 pour 100 au Canada entre 1974 et 1981. Dans les provinces de l'Atlantique, le TPS s'est caractérisé par une baisse générale entre 1974 et 1983. (p. 4 - 10)

-- Les émissions totales des deux usines de chlore de la région de l'Atlantique (une au Nouveau-Brunswick et une autre en Nouvelle-Ecosse) ont baissé de 75 pour 100 entre 1978 et 1984, principalement à la suite du respect des règlements fédéraux. (p. 33 - 36)

-- Les dépôts d'azote, qui résultent en grande partie du secteur des transports, ont doublé dans les provinces de l'Atlantique depuis 1954 et pourraient augmenter encore plus car, à moins de mesures de contrôle plus sévères, on prévoit une hausse de 30 pour 100 des émissions d'ici à la fin du siècle. (p. 40)

-- Le pH des échantillons de précipitation recueillis dans les provinces Maritimes varie entre 3,5 et 6,0, mais se situe entre 4,2 et 4,8 dans la plupart des cas. A titre de comparaison, le pH moyen des échantillons de pluie et de neige prélevés à Kentville, en Nouvelle-Écosse, entre 1952 et 1954 se chiffrait à 5,7. Le pH moyen de 16 lacs du Nouveau-Brunswick et de la Nouvelle-Écosse est passé de 6,3 dans les années 1950 à 5,7 en 1979. Une baisse d'une unité dans le pH signifie une hausse du taux d'acidité par un facteur de 10. (p. 38 - 46)

-- Au Nouveau-Brunswick, le taux d'érosion du sol a plus que quintuplé depuis 1945. (p. 61 - 64)

-- Entre 1972 et 1982, on est parvenu à réduire le nombre de sources de pollution ponctuelles du bassin hydrographique de la Saint-Jean de 88 pour 100 pour la demande biologique d'oxygène (DBO) et de 82 pour 100 pour les particules en suspension (PS). (p. 65) On a assisté à une amélioration soutenue de ces deux formes de pollution pour l'ensemble de l'industrie des pâtes et papiers dans les provinces de l'Atlantique. Ainsi, entre 1969 et 1984, la DBO a diminué d'environ 60 pour 100 et les PS de 51 pour 100. (p. 80-83)

-- Le Nouveau-Brunswick a signalé 71 fuites de réservoirs et de pipelines en 1983, 10 fois plus qu'au cours de la dernière décennie. (p. 75)

-- L'Electric Reduction Company (ERCO), située à Long Harbour, Terre-Neuve, a réduit ses déversements de phosphore de 70 à 90 pour 100 entre 1974 et 1984. De plus, entre 1975 et 1980, la même société est parvenue à épurer son effluent qui, de continuellement toxique est devenu presque toujours non toxique, grâce à de meilleures installations de traitement. (p. 93)

-- On encourage de plus en plus l'utilisation du charbon dans les provinces de l'Atlantique. Ainsi, on a brûlé 74 pour 100 plus de charbon en 1982 qu'en 1978. (p. 94)

-- Le nouveau système de traitement de la fonderie de plomb de Belledune a permis de réduire la concentration de cadmium dans l'effluent de 97 pour 100 depuis 1980. (p. 136)

-- Les provinces de l'Atlantique ne recyclent que 5 pour 100 des eaux industrielles usées comparativement à 18 pour 100 pour l'Ontario. On pourrait recycler au moins 15 pour 100 de plus du volume total de déchets dangereux produits dans la région et une proportion additionnelle de 45 pour 100 pourrait être éliminée par d'autres méthodes. (p. 166)

-- En 1984, 433 déversements de pétrole et de produits chimiques ont été signalés au Service de protection de l'environnement (SPE) dans les provinces de l'Atlantique, comparativement à 348 en 1981. Si le nombre total de déversements a augmenté, celui de déversements supérieurs à 2 275 litres (qualifiés de majeurs) enregistré dans la région a diminué au cours des années 1980. (Voir tableau 26, p. 178)

Qualité de l'air

L'air des provinces de l'Atlantique est généralement plus propre qu'il ne l'était il y a cinq ans, grâce aux efforts déployés par les industries et les gouvernements, mais des problèmes subsistent toujours. L'air des villes véhicule moins de particules -- la concentration totale de particules en suspension dans l'air à Halifax, à Charlottetown, à Saint-Jean et à Fredericton est constamment inférieure à la moyenne pour le Canada et les États-Unis et répond aux objectifs "visés".

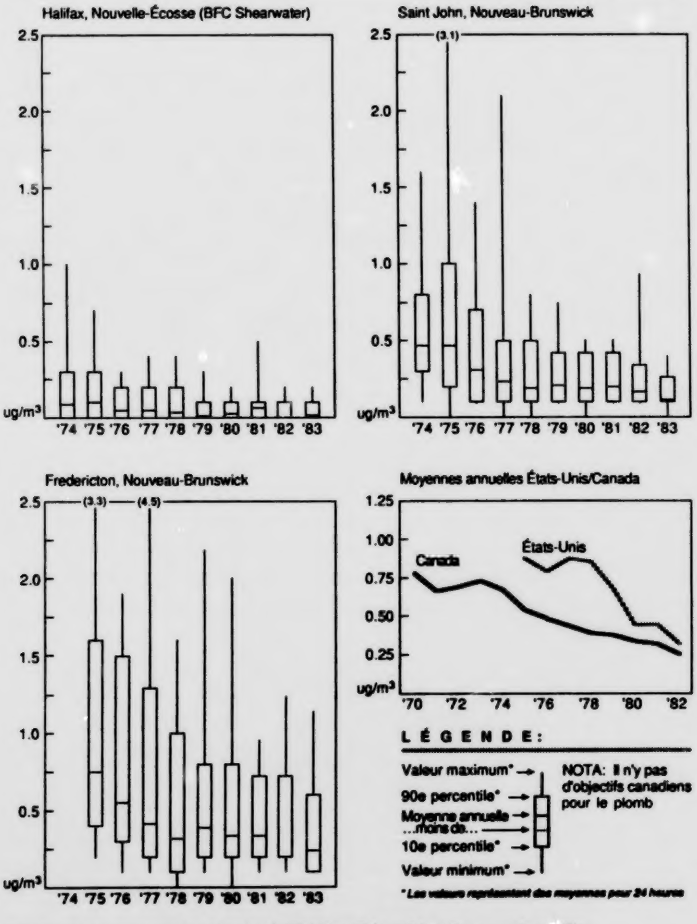
Déjà, le règlement fédéral portant sur la réduction du plomb dans l'essence a amené une baisse soutenue de la quantité de plomb présente dans l'air de la région, la principale source d'émission (supérieure à 70 pour 100) étant l'automobile. La concentration de plomb devrait diminuer encore plus quand les nouvelles lignes directrices fédérales, plus sévères, entreront en vigueur l'an prochain. Les détaillants d'essence des Maritimes, qui transgressaient le plus le règlement sur l'essence sans plomb autrefois, se sont tellement améliorés depuis 1979 que la région enregistre maintenant un taux d'infraction inférieur à la moyenne nationale.

Le Canada a interdit l'emploi des aérosols renfermant des fluorocarbones en 1980 car ces derniers détruisent la couche d'ozone de l'atmosphère qui protège la terre des rayons ultra-violets. Cependant, si l'ozone stratosphérique est désirable, diverses recherches ont récemment démontré que l'ozone était également produit au niveau du sol par réaction photochimique entre certains gaz et les rayons solaires. On considère que l'ozone du sol est un polluant dangereux pour la santé, et la plupart des rapports qui émanent des stations de surveillance des provinces de l'Atlantique montrent que le seuil maximum tolérable a déjà été dépassé.

Par ailleurs, on assistera vraisemblablement à une hausse de la concentration d'hydrocarbures aromatiques polycycliques (HAP) dans les provinces de l'Atlantique au cours des quelques prochaines années à la suite de la conversion des centrales thermiques du pétrole au charbon et de l'augmentation du chauffage au bois dans les maisons. Si les poêles et les foyers contribuent à rendre la vie plus agréable, la combustion du bois augmente néanmoins la quantité de HAP et de particules en suspension dans l'air.

Un problème beaucoup plus localisé existe à Terre-Neuve. Malgré une campagne de nettoyage de plusieurs millions de dollars, on s'inquiète toujours de la forte concentration d'amiante dans l'air de la région de Baie Verte. Il semble que cette situation est causée par la poussière d'amiante libérée avant le lancement de la campagne et il est possible que la suppression des sources voisines améliore la situation.

PARTICULES DE PLOMB



Tendances des concentrations de plomb (Pb) dans l'air ambiant dans certaines villes de la région de l'Atlantique (1974-1983)

Qualité de l'eau

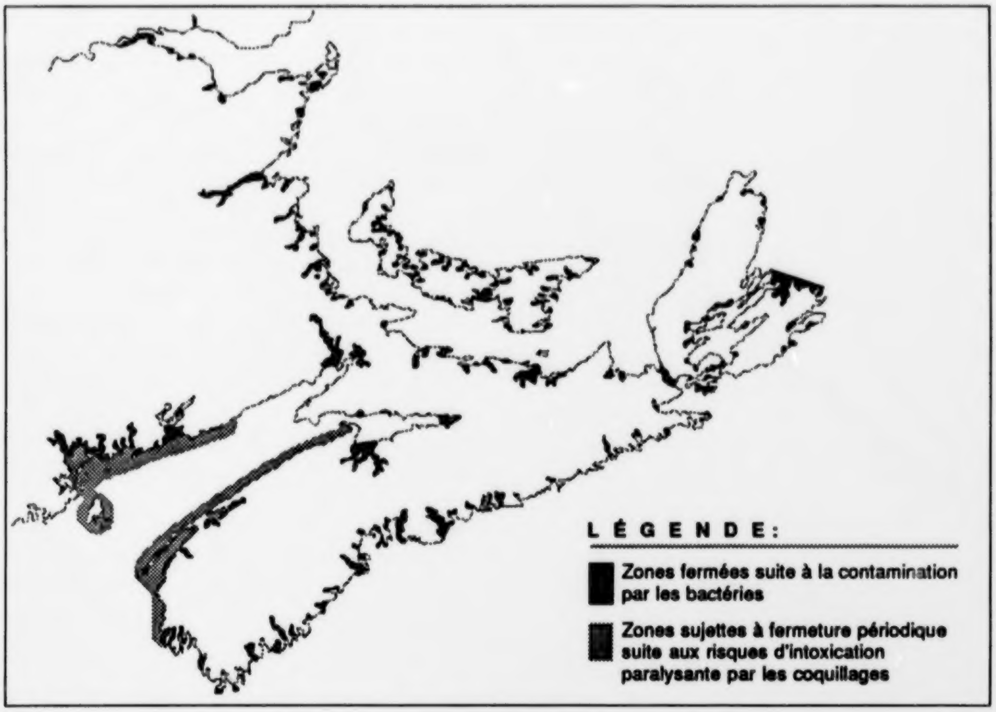
Les eaux intérieures sont essentielles à la faune et au poisson et jouent un rôle capital comme source d'eau potable, pour la production agricole et industrielle ainsi que dans nos loisirs, en plus d'avoir une qualité esthétique intrinsèque. La plupart des sources publiques d'eau potable dans la région respectent habituellement les limites acceptables établies dans les lignes directrices, mais certaines échouent couramment sur ce plan, ce qui est intolérable. En règle générale, il y a assez d'eau douce pour l'irrigation et les activités industrielles.

La contamination des sources d'eau domestique par les produits chimiques commence à avoir une incidence économique sur les habitants des provinces de l'Atlantique, de plus en plus de contribuables étant obligés d'abandonner les puits ou les systèmes d'approvisionnement existants pour en trouver de nouveaux. Bien qu'on assiste à une contamination de plus en plus évidente de la nappe phréatique, seule une petite partie des sources d'approvisionnement est touchée.

La pêche sportive et commerciale constitue à la fois une forme de loisir et une source importante de revenus sur la côte de l'Atlantique. Même si la population de saumons et de truites semble avoir diminué au cours du dernier quart de siècle, le taux de contamination dépasse rarement le seuil tolérable pour la consommation humaine. Au cours des 10 dernières années, on a apporté des améliorations aux rivières fortement carencées en oxygène, en particulier celles polluées par les effluents des usines de pâtes et papiers et des municipalités. La meilleure oxygénation de la rivière Sainte-Croix (à la frontière du Nouveau-Brunswick et du Maine), par exemple, a amené le retour des saumons.

Les eaux côtières semblent les plus durement touchées par la vie moderne et la nature. De plus en plus de zones consacrées à la conchyliculture doivent être fermées en raison du déversement d'eaux industrielles et municipales ainsi que de menaces naturelles comme les marées rouges. Les effluents miniers, les eaux usées municipales, l'envasement, l'eau de ruissellement polluée par les produits agrochimiques, les obstacles au passage des poissons et les pluies acides ont également détérioré l'habitat du poisson.

En 1983, 262 zones de ramassage des coquillages ont dû être fermées, soit 25 de plus qu'en 1979. Vingt-deux pour cent des zones de production des myes de la région Scotia-Fundy ont été interdites à la suite d'une hausse de la contamination de l'eau par les matières fécales et d'un contrôle plus sévère par les autorités fédérales. C'est grâce à cette surveillance accrue qu'aucune épidémie grave de maladies intestinales ne s'est déclarée depuis 1972 à la suite des pêches effectuées dans les zones autorisées.


LÉGENDE:
■ Zones fermées suite à la contamination par les bactéries
▨ Zones sujettes à fermeture périodique suite aux risques d'intoxication paralysante par les coquillages

Zones de ramassage des coquillages contaminées dans les Maritimes (1985)

La pêche des huîtres, des myes et des moules représente toujours un apport annuel de 5 millions de dollars à l'économie des provinces de l'Atlantique, mais la fermeture des zones de pêche a entraîné une hausse du taux de chômage, une baisse du tourisme et l'escalade du prix de ces produits pour les consommateurs.

Les conséquences économiques malheureuses de la pollution des côtes pour l'industrie locale des mollusques sont bien illustrées à la baie de Caraquet, dans la partie nord-est du Nouveau-Brunswick. Soixante-dix pour cent des huîtres du Nouveau-Brunswick sont pêchées à cet endroit, même si on a interdit l'accès à 2 400 hectares de la baie en raison de la contamination par les matières fécales. A l'heure actuelle, on estime que la pêche commerciale des mollusques dans la baie génère 500 000 $. Si l'on éliminait les problèmes dus à la pollution, la production annuelle d'huîtres pourrait rapporter 2 millions de dollars.

Une telle amélioration est possible. Ainsi, le nouveau système de traitement des effluents à la fonderie de plomb de Belledune, dans le nord du Nouveau-Brunswick, a réduit la concentration de cadmium de 97 pour 100 depuis 1980, époque où l'on avait dû interdire la pêche du homard dans le port de cette ville. La baisse des concentrations de cadmium dans le homard a permis la réouverture de la pêche en 1985, sous réserve d'une mise en marché réglementée.

Les eaux du large semblent néanmoins en bonne condition, le degré de contamination y étant constamment inférieur au seuil nécessaire à la manifestation d'effets visibles. Ainsi, la quantité de résidus de DDT relevée dans la couche de lard des phoques gris de l'île au Sable en 1982 était inférieure à celle des échantillons comparables prélevés en 1974. Il s'agit de la première indication dénotant clairement une diminution des résidus du groupe du DDT à la suite de l'interdiction d'utilisation introduite au début des années 1970. Cependant, on trouve de plus en plus souvent des déchets constitués de substances réfractaires à la biodégradation comme le plastique, ce qui nuit à l'aspect esthétique de l'environnement et réduit le potentiel touristique de la région.

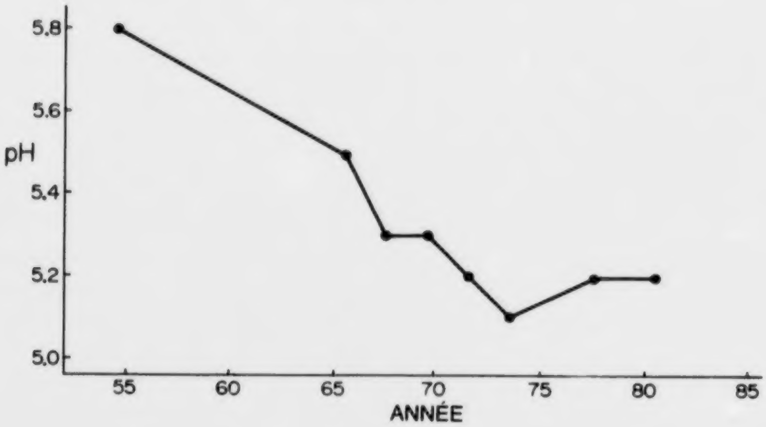
Pluies acides

Les pluies acides se forment dans l'atmosphère sous l'action de l'anhydride sulfureux (SO_2) et des oxydes d'azote (NOx) libérés par la combustion des combustibles fossiles. Soixante-quinze à 80 pour 100 des dépôts d'anhydride sulfureux dans les provinces de l'Atlantique proviennent du centre du Canada et du nord des États-Unis. Les centrales thermiques sont la principale source locale de SO_2.

Les effets des pluies acides se font sentir au niveau des lacs, des rivières et des précipitations qui subissent une variation du pH. Le terme "pH" désigne la mesure du degré d'acidité sur une échelle de 1 à 14, la valeur 7 correspondant au point neutre. Les valeurs inférieures à 7 sont un signe d'acidité et la baisse d'une unité (par exemple de 6 à 5) signifie que le taux d'acidité a augmenté d'un facteur de 10.

Le pH de la neige, de la pluie et des autres précipitations échantillonnées dans les provinces de l'Atlantique varie actuellement entre 3,5 et 6,0, la majorité des prélèvements se situant entre 4,2 et 4,8. Par comparaison, le pH moyen des échantillons de pluie et de neige recueillis à Kentville (N.-E.) entre 1952 et 1954 se chiffrait à 5,7. Par ailleurs, la moyenne de 16 lacs du Nouveau-Brunswick et de la Nouvelle-Écosse est passée de 6,3, durant les années 1950 à 5,7 en 1979. On estime que les poissons commencent à souffrir de l'acidité quand le pH tombe en-dessous de 6,0; la plupart des poissons ne peuvent survivre à un pH inférieur à 4,5. La hausse de l'acidité peut agir sur les populations animale et végétale qui servent de nourriture aux poissons et à leurs proies. L'eau acide mobilise ou dissout également les métaux des sédiments qui se trouvent dans la colonne d'eau et expose les poissons à une concentration accrue de métaux toxiques. Il est souvent difficile de distinguer les effets de la pluie acide sur la vie aquatique des effets d'autres facteurs d'agression comme une pêche excessive, un changement physique de l'habitat et la présence d'autres contaminants.

Les pluies acides détériorent également le milieu humain. Ainsi, elles peuvent accélérer l'érosion des bâtiments, de la peinture et des automobiles. On estime que les dommages dus à ce phénomène dépassent annuellement 285 millions de dollars au Canada et 5 milliards de dollars en Amérique du Nord. Cependant, son aspect le plus dangereux reste son rayon d'action. Rares sont les formes de pollution capables de détruire la vie aquatique d'une étendue d'eau apparemment pure, à une si grande distance.

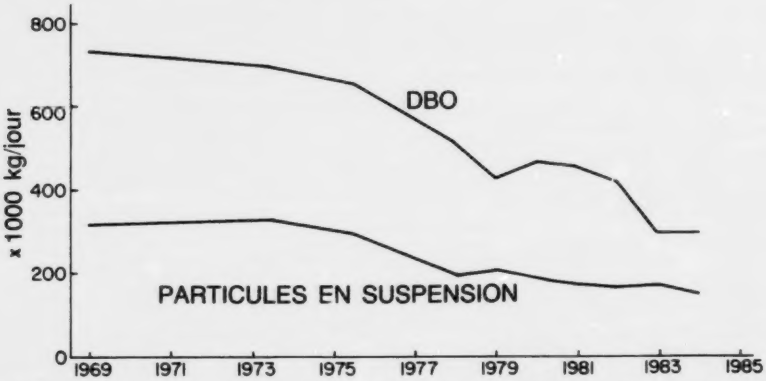


Chute du pH dans la rivière Medway (Nouvelle-Écosse)

Foresterie et agriculture

La composition des forêts des provinces de l'Atlantique a sensiblement changé depuis la colonisation. L'abattage intensif, les feux de forêt et les maladies ont permis aux sapins baumiers et aux épinettes, deux espèces très sensibles à la tordeuse des bourgeons de l'épinette, de prédominer. Les infestations de tordeuses les plus récentes ont à toutes fins pratiques détruit la forêt de sapins et d'épinettes des hauts plateaux du Cap Breton en plus de tuer des conifères à l'intérieur des terres au Nouveau-Brunswick, en Nouvelle-Ecosse et à Terre-Neuve. On s'attend à une augmentation de la coupe à blanc et à un reboisement intensif avec une seule espèce dans l'avenir, ce qui devrait accroître encore plus la sensibilité des forêts aux maladies et aux infestations.

On a pu relever, cependant, certaines améliorations. Ainsi, les usines de pâtes et papiers ont considérablement réduit leur volume d'effluent au cours des dernières années. La quantité de déchets potentiellement toxiques, à haute demande d'oxygène (DBO), déversée dans les provinces de l'Atlantique a diminué de 60 pour 100 alors que celle de particules en suspension a baissé de 51 pour 100. Un programme de modernisation quinquennal fédéral-provincial a été amorcé dans 13 des 20 usines de la région en 1980-1981. En 1984, neuf établissements se conformaient aux règlements fédéraux sur les effluents de pâtes et papiers de la Loi sur les pêcheries en ce qui concerne les particules en suspension et trois autres les suivaient de près. Par ailleurs, 10 usines se conformaient aux normes pour la DBO et quatre autres étaient sur le point de le faire.



Effluent des usines de pâtes et papiers de la région de l'Atlantique -Tendances (1969 à 1984)

Le nombre de produits chimiques utilisés comme pesticides n'a cessé d'augmenter au fil du temps. Le 1er janvier 1985 par exemple, 514 antiparasitaires étaient homologués au Canada comparativement à 30 en 1940 et à environ 400 en 1979. Auparavant, dans la région, la surveillance s'exerçait principalement sur les insecticides et, dans une moindre mesure, sur les désherbants forestiers. Cependant le sort, la persistance et les incidences environnementales des pesticides agricoles sont récemment devenus le point de mire des efforts de surveillance, même si peu d'études régionales ont été complétées sur ce sujet. Il n'en reste pas moins que le sol des terres arables du Canada reçoit actuellement 15 fois plus d'insecticide que celui de nos forêts.

Les pratiques culturales existantes sont principalement à l'origine du problème d'envasement qui ne cesse de s'accentuer d'année en année à l'Île-du-Prince-Edouard et dans diverses parties du Nouveau-Brunswick. Les champs de grande superficie sans haies protectrices suffisantes résistent moins à l'érosion éolienne. Il est également courant de labourer le sol à l'automne, ce qui l'expose encore plus à l'érosion par le vent et l'eau en hiver et au printemps. Au Nouveau-Brunswick, le taux d'érosion actuel est cinq fois plus élevé qu'en 1945 et les agriculteurs de la partie ouest de la province assistent chaque année à la disparition de 22,5 à 45 tonnes de sol par hectare, alors que le seuil de tolérance maximal recommandé par le ministère de l'Agriculture du Nouveau-Brunswick se situe à neuf tonnes par hectare par année.

En l'absence de ceintures de verdure ou d'autres mesures protectrices, 25 à 40 pour 100 du sol emporté échoue dans l'eau, avec les métaux, les minéraux et les autres polluants qu'il contient. Récemment, on a déployé de nombreux efforts pour essayer de renverser cette dangereuse tendance. L'adoption générale de normes environnementales pour la construction de chemins forestiers et le maintien de bandes de végétation le long des cours d'eau de la région pourrait atténuer une partie du problème. Les principales victimes de l'envasement sont sans doute le saumon et la truite. En effet, en plus de polluer l'eau, le limon cache les gravillons dans lesquels ces deux espèces déposent leurs oeufs.

Déchets dangereux et produits toxiques

La gestion et l'élimination des déchets dangereux sont devenues prioritaires partout au Canada. Dans la région de l'Atlantique, l'intérêt des médias pour divers incidents, comme la contamination d'un dépotoir d'Amherst (N.-E.) par les BPC et l'abandon de fûts d'herbicides dans de vieux dépotoirs du Nouveau-Brunswick, a suscité l'inquiétude du public. Malgré cela, la question de l'élimination, du transport et du stockage des déchets dangereux est loin d'être résolue.

Quatre cent trente-trois déversements de pétrole et de produits chimiques ont été signalés dans les provinces de l'Atlantique en 1984, comparativement à 348 en 1981. Néanmoins, si le nombre total de déversements a augmenté, celui de déversements supérieurs à 2 275 litres, qualifiés de "majeurs" par les représentants du ministère de l'Environnement, a connu une baisse au cours des années 1980.

Les Maritimes traînent de l'arrière en ce qui concerne la construction d'installations de traitement des eaux usées. Plusieurs petites communautés sont pourvues d'un système d'épuration des eaux usées, mais les centres plus importants, comme Halifax, Dartmouth, Sydney, Edmundston et Saint-Jean, qui sont aussi les plus anciens, ont des installations insuffisantes, lorsqu'elles existent.

De plus en plus, on remarque la présence de produits chimiques toxiques dans les eaux douces des provinces de l'Atlantique. Ces produits, organiques ou inorganiques, émanent de sources naturelles et artificielles situées dans la région ou à l'extérieur. Si l'on s'inquiète de leur présence dans l'eau douce, c'est que ces produits ont une forte tendance à se disperser, à être très persistants et à s'accumuler dans les tissus organiques, ce qui peut entraîner des modifications biologiques, même à l'état de traces.

La contamination de la nappe phréatique vient à peine d'être reconnue comme une menace grave pour la région, compte tenu du nombre croissant de cas de contamination par les bactéries, le sel, les nitrates, les pesticides et les dérivés du pétrole. Ainsi, au Nouveau-Brunswick, on a rapporté 71 fuites de réservoirs et de pipelines en 1983, 10 fois plus qu'au cours de la dernière décennie.

L'eau souterraine des provinces de l'Atlantique est de plus en plus polluée par des matériaux qui ont été enfouis dans le sol ou s'y sont déversés. Les lieux d'élimination restent les principaux points chauds, car peu d'entre eux sont exploités correctement. En règle générale, les cas de contamination devraient être de plus en plus nombreux dans la région au cours des prochaines années.

Des programmes de dépollution ont déjà été lancés à certains endroits. Un exemple est celui des "amas goudronneux" de l'aciérie de la Sysco à Sydney, Nouvelle-Écosse. Même si de graves problèmes de pollution de l'air et de l'eau persistent, les mesures de dépollution et le ralentissement de la production ont réduit la quantité de déchets produits par la Sysco au cours des dernières années. Des études techniques sur les façons d'éliminer ou de traiter et de restreindre le lessivage des amas goudronneux viennent à peine d'être terminées.

Les polluants ne dérivent pas tous de l'activité humaine. L'arsenic existe à l'état naturel et finit parfois par se retrouver dans l'eau des puits. Dans le comté de Halifax, la contamination des puits de plusieurs communautés par l'arsenic est un phénomène connu depuis une dizaine d'années. Vingt-trois pour 100 des échantillons analysés indiquaient que la concentration d'arsenic dépassait de cinq fois le seuil maximal tolérable. Des symptômes d'intoxication chronique à l'arsenic ont été relevés chez approximativement 30 pour 100 des habitants de Waverley (N.-É.) qui boivent l'eau des puits contaminés.

Il est possible de recycler certains déchets dangereux, mais seulement 5 pour 100 des résidus industriels de la région le sont comparativement à 18 pour 100 en Ontario. Quinze pour 100 de plus de la quantité totale de déchets dangereux de la région se prêteraient au recyclage et d'autres méthodes permettraient d'en éliminer un autre 45 pour 100.

Énergie et environnement

La production d'énergie dans notre société moderne est à l'origine d'une foule de problèmes. La combustion du charbon et du pétrole peut être une source de pluies acides et nuire à la qualité de l'air ambiant. L'énergie hydro-électrique peut modifier la qualité et le volume de l'eau alors que la combustion du bois de chauffage peut agir sur la diversité des écosystèmes forestiers et la qualité de l'air. D'un autre côté, l'énergie nucléaire, qui est devenue une réalité dans la région de l'Atlantique en 1983 avec l'inauguration de la centrale de Pointe Lepreau, suscite la controverse.

Dans la région de l'Atlantique, le charbon est surtout utilisé pour produire de l'électricité; des quantités plus réduites sont destinées aux secteurs industriel et commercial. On s'attend à ce que la consommation de charbon continue d'augmenter et finisse par se stabiliser pour répondre à 22 pour 100 de la demande énergétique de la région d'ici à la fin des années 1990.

L'utilisation accrue du charbon pourrait avoir de profondes conséquences pour l'environnement. L'extraction du charbon peut entraîner l'écoulement d'eaux acides près des mines qui, à leur tour, peuvent altérer la qualité du sol et de l'eau et détruire les poissons. Par ailleurs, le transport du charbon libère des poussières susceptibles de polluer le milieu ambiant.

La combustion du charbon, qui renferme du soufre, contribue fortement aux pluies acides. Certains charbons de la région sont riches en soufre et contiennent une quantité importante de plomb, de chrome, d'aluminium, d'uranium et d'arsenic qui peuvent se retrouver en concentrations dans les cendres ou être libérés dans l'air. Néanmoins, de nouvelles techniques de combustion sont actuellement à l'essai à Summerside (Î.-P.-É.), Pointe Tupper (N.-É.) et Chatham ainsi qu'à la base des Forces canadiennes de Gagetown (N.-B.). Ces nouvelles méthodes (y compris la combustion sur lit fluidisé, la boue de charbon et d'eau et le brûleur à injection de chaux) pourraient sensiblement réduire les émissions de SO_2 et de NO_x des centrales alimentées au charbon.

Les centrales hydro-électriques produisent 79 pour 100 de l'électricité distribuée dans la région de l'Atlantique. La Société hydro-électrique de Terre-Neuve et du Labrador tente, à l'heure actuelle, d'élaborer un plan de protection de l'environnement applicable aux futures lignes de haute tension et à leurs corridors. Barrages et lignes de haute tension peuvent avoir divers effets sur la faune et son habitat, effets qui ne sont d'ailleurs pas tous négatifs. Toutefois, les aménagements hydro-électriques sur la rivière Saint-Jean ont réduit la capacité du cours d'eau à absorber les résidus, ce qui a causé la mort du poisson par épuisement de l'oxygène dans les bassins principaux.

La meilleure façon de réduire le coût de l'énergie tant sur le plan économique qu'environnemental est par la conservation. D'ici à l'an 2000, on estime que l'industrie canadienne consommera 32 pour 100 moins d'énergie qu'en 1978 pour fabriquer les mêmes produits. Dans la région, on poursuit des recherches sur de nouvelles sources d'énergie comme les déchets municipaux, le biogaz, les combustibles à base d'alcool, la tourbe, l'énergie solaire, éolienne ou géothermique. De plus, les provinces de l'Atlantique comptent l'une des trois seules usines marémotrices au monde. Néanmoins, si ce type de centrale produit une énergie "propre", on sait d'ores et déjà qu'elle peut provoquer des inondations et créer un obstacle physique pour le poisson.

Conclusion

La qualité de l'environnement dans la région de l'Atlantique (1985) ne renferme pas de statistiques sur tous les aspects de l'environnement de cette région. Le rapport n'a pas été conçu pour pointer du doigt certaines sources de pollution précises, ni pour formuler des recommandations. Il brosse cependant un tableau de l'écosystème de la région de l'Atlantique. C'est un instantané. Il s'agit du second rapport du genre pour cette région et il fait partie de la série nationale de rapports sur l'environnement lancée par Environnement Canada. Nous prévoyons publier ces rapports à intervalles de quelques années. Au fil du temps, nous aurons l'occasion de comparer ces instantanés, de les utiliser pour définir les tendances et identifier l'origine des problèmes environnementaux. Pour l'instant, le rôle de ce document est de renseigner le public sur la condition de l'air, du sol et de l'eau dans les provinces de l'Atlantique et d'offrir aux associations, aux organismes et aux gouvernements intéressés un point de repère ainsi que des données pour les guider dans leurs décisions et leurs politiques.

Pour plus de renseignements ou obtenir un exemplaire du rapport, communiquer avec :

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Dartmouth (Nouvelle-Ecosse)
B2Y 2N6

Ou composer :

(902) 426-6141

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Environmental Quality in the Atlantic Region 1985

Canadä

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Environmental Quality in the Atlantic Region 1985

P. B. Eaton, L. P. Hildebrand and A. A. d'Entremont

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Acronyms and Abbreviations

AECB -- Atomic Energy Control Board
ARPAC — Atlantic Region Pesticides Advisory Committee
BaP — benzo(a)pyrene
BOD — biological oxygen demand
CIL — Canadian Industries Limited
CO — carbon monoxide
CO_2 — carbon dioxide
CWS — Canadian Wildlife Service
DDT — dichlorodiphenyltrichloroethane (pesticide)
DFO — Department of Fisheries and Oceans
DOE — Department of the Environment (also EC)
EARP — Environmental Assessment and Review Process
EC — Environment Canada (also DOE)
EIA — environmental impact assessment
EIS — environmental impact statement
EMR — Department of Energy, Mines and Resources
EPS — Environmental Protection Service
ERCO — Electric Reduction Company
FAO — Food and Agriculture Organization (United Nations)
GSHP — groundwater source heat pump
H_2S — hydrogen sulphide
IBP — International Biological Programme
LRTAP — long range transport of air pollution
MOT — Ministry of Transport
NAPS — National Air Pollution Surveillance (Network)
NAQO — National Air Quality Objective
NBDOE — New Brunswick Department of the Environment (now NBMAE)
NBMAE — New Brunswick Municipal Affairs and Environment
NEP — National Energy Program
NH&W — Department of National Health and Welfare
NOx — oxides of nitrogen
NSDOE — Nova Scotia Department of the Environment
NSPC — Nova Scotia Power Corporation
O_3 — ozone
ODCA — Ocean Dumping Control Act
PAH — polycyclic aromatic hydrocarbons
Pb — lead
PCB — polychlorinated biphenyl
PCP — pentachlorophenol

p,p'-DDE — 1,1'-(2,2-dichloroethenylidene)-bis(4-chlorobenzene) (pesticide)
PSP — paralytic shellfish poison
RSCC — Regional Screening and Coordinating Committee
SO_2 — sulphur dioxide
SPM (TSP) — suspended particulate matter (total suspended particulates)
SS — suspended solids
Sysco — Sydney Steel Corporation
2,3,7,8-TCDD — 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin)
2,4-D — 2,4-dichlorophenoxyacetic acid (pesticide)
2,4,5-T — 2,4,5-trichlorphenoxyacetic acid (pesticide)
TCE — trichloroethylene
TDGA — Transport of Dangerous Goods Act
U.S. EPA — United States Environmental Protection Agency

Units of Measurement

Bq — becquerel
cm — centimetre
Gwh — gigawatt hour
ha — hectare
kg — kilogram
km — kilometre
kt — kilotonne
kts — knots
kw — kilowatt
l (L) — litre
m — metre
μg — microgram
mg — milligram
mta — million tonnes per annum
ng — nanogram
ppb — parts per billion
ppm — parts per million

Glossary

Acute Toxicity — Poisoning generally caused by short-term exposures to high levels of one or more toxic agents. Symptoms appear soon after exposure, and death occurs if exposures are prolonged.

Adsorption — The retention of gases, dissolved materials, or ions on the surface of solid particles, including organisms and substrates.

Alkalinity — The acid-neutralizing capacity of water; the quality and quantity of constituents in water which result in a shift in the pH above 7 (neutral).

Ambient Air Quality Standard — Maximum permissible concentration of a pollutant in the air.

Anadromous — Describes fish, such as salmon and shad, that ascend freshwater streams from the sea to spawn.

Anencephaly — A congenital malformation in which all or most of the brain and flat skull bones are absent.

Anoxic — Absence of oxygen.

Aquifer — An underground permeable body of rock or soil holding or transmitting quantities of water which can supply wells and springs.

Arithmetic Mean — The average of a set of numbers, obtained by dividing their sum by the number in the set.

Bioaccumulation — The process whereby chemicals are taken up by organisms from air or water directly, or through the consumption of food containing the chemicals.

Biological Oxygen Demand (BOD) — Measure of oxygen depletion of water due to bacterial decay of organic pollutants. Gives an indication of how much organic matter is in the water.

Biomagnification — Buildup of contaminants in organisms in successively higher trophic levels.

Buffering Capacity — A measure of the resistance of water to decreases or increases in pH upon addition of acid or base respectively.

Carcinogen — A chemical or physical agent that causes cancer.

Chronic Toxicity — Poisoning generally caused by long-term exposures to low levels of one or more toxic agents. Symptoms may appear long after exposure.

Cistern — A tank for storing water.

Cocarcinogen — A non-carcinogenic agent which augments the carcinogenic process.

Congenital — A disease or defect dating from birth or from before birth.

Contaminant — Any physical, chemical, or biological substance which is introduced into the environment. Does not imply an effect (see pollution). Usually refers to man-made substances.

Environmental Quality — The condition of an environment (air, land, water, including biota) measured relative to each intended use for specific portions of the environment. It is usually assessed against objectives and limits set by environmental and resource agencies, but it often includes subjective perceptions of what is considered desirable or acceptable.

Eutrophication — The process whereby nutrients are accumulated in a water body due to human intervention or natural causes. This usually increases the productivity of aquatic plants to a point where dissolved oxygen becomes depleted, and water quality in general seriously declines.

Hepatopancreas — A gland in lobsters and certain other invertebrates that combines the digestive functions of the liver and pancreas of vertebrates.

Inorganic — Matter other than plant or animal, and not containing a combination of carbon/hydrogen/oxygen as in living things.

Mutagen — A chemical or physical agent capable of damaging the genetic material (DNA or chromosomes) of living organisms.

Neural tube — The embryonic tube that differentiates into brain and spinal cord.

Order of Magnitude — Ten times.

Palatable — Pleasant or acceptable to the taste.

Pathogenic — Producing or capable of producing disease.

Perinatal — The period closely surrounding the time of birth.

pH — Measure of acidity on a scale from 0 to 14, with pH 7 being neutral, numbers greater than 7 being basic, and numbers less than 7 being acidic. Each number on the scale represents a difference of ten.

Photochemical Reaction — A chemical reaction influenced or initiated by light, particularly ultraviolet light.

Pollution — Any physical, chemical or biological alteration of air, water or land that is harmful to living organisms (different from contamination).

Potable — Suitable for drinking.

Precursor — A substance that preceeds and is the source of another substance.

Primary Treatment — The first step in sewage treatment to remove large solid objects by screens, and sediment and organic matter in settling chambers.

Proponent — Person or agency who makes a proposal for a project.

Red Tide — A reddish discolouration of coastal surface waters due to concentrations of certain toxin-producing dinoflagellates (microscopic planktonic organisms).

Sanitary Landfill — Solid waste disposal site where garbage is dumped in the ground and covered daily with a layer of dirt to reduce odours, insects and rats.

Secondary Treatment — The second step in sewage treatment, involving removal of biodegradable organic matter using bacteria, other microorganisms, and aeration.

Silviculture — The theory and practice of controlling the establishment, composition and growth of stands of trees.

Spina Bifida — A congenital anomaly characterized by defective closure of the vertebral canal.

Sublethal — Below the concentration that directly causes death. Exposure to sublethal concentrations of a material may produce less obvious effects on behaviour, development, reproduction, and biochemical and/or physiological functions of organisms.

Teratogen — A chemical or physical agent capable of causing developmental defects, particularly near or shortly after birth.

Toxicity — The inherent potential or capacity of a material to cause adverse effects in living organisms.

Water Quality Guideline — Numerical concentration limit or narrative statement recommended to support and maintain a designated water use.

Water Quality Objective — Numerical concentration limit or narrative statement, which has been negotiated to support and protect the designated uses of water at a specified site.

Water Quality Standard — An objective that is recognized in enforceable environmental control laws of a level of government.

Foreword

This 1985 report on environmental quality in the Atlantic region describes aspects of the current state of the environment, as well as certain trends that can be compared to those in a similar report published five years earlier[28]. The Atlantic region of Canada, consisting of New Brunswick, Newfoundland/Labrador, Nova Scotia and Prince Edward Island, has a population of 2,285,000 (9.1 percent of Canada), most of which is located within a few miles of the 40,000 km coastline (Figure 1). A healthy natural environment is important because the regional economy will continue to revolve around the renewable resource industries of fishing, forestry, agriculture and tourism, all of which require a suitably high level of environmental quality to thrive.

What is environmental quality? One definition states it as "essentially a subjective measurement based largely on value judgements of what we consider desirable in the environment". If we accept this as a reasonable definition it becomes clear that the demands for environmental quality, for example of a river valley, will differ for the ecologist, the salmon fisherman, the farmer or the mill manager. Each has a special set of values; and each will tolerate a certain level of change before becoming dissatisfied with his or her environment. It is indeed a subjective measure.

It therefore follows that an environmental quality report such as this is, to a large degree, limited to describing the condition of the environment using certain objective measurements, reporting changes in these measurements (trends), or describing their deviation from some standard. The question of whether the state of the environment is good or bad is left largely up to you, the reader. This report does attempt to provide sufficient information to allow you to make a subjective evaluation of environmental quality in Atlantic Canada, but, in some instances, an interpretation or an assessment of the state of the environment is offered.

This report, while attempting to be comprehensive, cannot possibly cover every environmental issue in the region. There are sections on air quality, freshwater and marine water quality, toxic chemicals, acid precipitation, hazardous wastes, groundwater contamination and nature conservation. The data upon which the report is based have been drawn from various sources including the current scientific literature, and from monitoring and investigations carried out by provincial and federal departments.

The report highlights changing aspects of environmental quality; some positive, others negative. For example, industrial air and water pollution has been reduced in some areas, and concentrations of some chemicals in the environment, such as DDT and PCBs, appear to be declining in certain indicator species. On the negative side, the impacts of acid

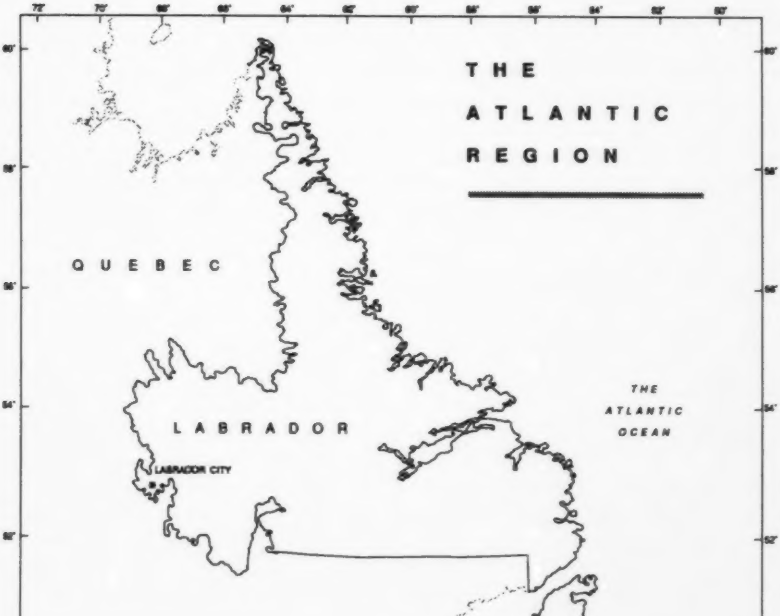
THE ATLANTIC REGION
QUEBEC
LABRADOR
LABRADOR CITY
THE ATLANTIC OCEAN
GULF OF ST LAWRENCE
EXPLOITS R.
GANDER
CORNER BROOK
NEWFOUNDLAND
ST JOHN'S
RESTIGOUCHE R.
BATHURST
MIRAMICHI R.
NEW BRUNSWICK
P. E. I.
CHARLOTTETOWN
SYDNEY
MONCTON
SAINT JOHN R.
SAINT JOHN
NOVA SCOTIA
SHUBENACADIE R.
HALIFAX
MAINE
BAY OF FUNDY
YARMOUTH
SABLE I.
0
100
200
KM

Figure 1 The Canadian Atlantic region

precipitation, the contamination of groundwater by chemical substances, and the erosion of valuable forest and farm soils are becoming more evident. These negative changes may have been with us for some time, but only recently have studies revealed their magnitude. New and better analytical methods and improved laboratory testing have served to alert us to more complex environmental problems, and the relationship between environmental contamination and human health is slowly becoming clearer.

Advances in environmental management have had a positive influence on environmental quality. This is discussed in terms of the importance of public and corporate awareness of environmental sensitivities, and the value of supporting legislation. In addition, some of the current advances in environmental research are briefly discussed in order to provide a limited perspective on the role of such research in environmental quality assessment and protection.

To our knowledge, this report series is currently the only one of its kind in Canada. An attempt has been made to make it as informative and relevant as possible. We know, however, that there is room for improvement, hence we are asking that you take the time to send us your written comments, or simply to fill in the card at the end of the report and mail it to us. In that way, the next environmental quality report scheduled for 1989/90 will be of greater value to you.

J. Rod MacDonald, *Director*
Contaminants & Assessments Branch.

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Highlights

Air Quality

— Recent data indicate that the magnitude of most of (suspended particulate matter) emissions has decreased since 1980 (page 4).

— In the Atlantic Provinces, TSP (total suspended particulate) levels (in the ambient air) generally declined between 1974 and 1983 (page 5).

— (Nevertheless, the NAPS station next to the Sydney Steel Plant) . . . records some of the highest levels of TSP in the country (page 6).

— The average BaP level measured in Sydney at a site near the coke ovens . . . was higher than the average obtained from heavily industrialized cities with coke ovens such as Hamilton, Ontario . . . and certain U.S. cities . . . (page 8).

— Over the last few years residential wood heating has increased rapidly in the Atlantic region . . . (and) wood stoves can be substantial emitters of particulates, carbon monoxide, and a wide variety of organic compounds . . . (page 9).

— Thermal generating stations in New Brunswick and Nova Scotia emit nearly 87% of the total SO_2 *produced within the region (page 11).*

— . . . the mean ambient SO_2 *levels in the urban centres of the Atlantic region consistently ranged between the maximum desirable (1.0 pphm) and acceptable (2.0 pphm) objectives in the period 1974 to 1983 (page 12).*

— Atlantic region stations have been recording slightly lower ambient (NO_2*) levels in recent years than the rest of Canada and the United States . . . (page 15).*

— . . . ambient levels (of carbon monoxide) at the Atlantic stations generally match Canadian and U.S. levels (page 15).

— In the Maritimes, mean growing season concentrations (of ozone) are close to, but below the threshold for crop and forest effects . . . (page 20).

— The violation rate of the Lead-Free Gasoline Regulations at Atlantic region gasoline outlets had been consistently higher than the national violation rate, but has steadily declined since 1979 and has been lower than the national rate since 1982 (page 22).

— Nevertheless, data for the period 1974 to 1983 show a definite decline in the annual means (of lead) at all stations in the region (page 25).

— Total (atmospheric) mercury emissions from the two (chlor-alkali) plants declined by 75% from 1978 . . . to 1984 . . . (page 26).

— Up to 80% of the sulphur deposited in Atlantic Canada is emitted as sulphur dioxide (SO_2), principally from non-ferrous smelters and thermal power plants in Central Canada and the United States (page 29).

— Nitrogen deposition has doubled in Atlantic Canada since 1954 . . . (page 30).

— Aquatic environments in parts of the region have been altered due to acidic deposition. The pH of nine river systems in Nova Scotia has declined since 1955, to the point where Atlantic salmon cannot reproduce successfully. Salmon populations in twenty-two other Nova Scotian rivers are seriously threatened (page 32).

— Acid rain is considered by many Atlantic Canadians to be the major environmental issue in the region (page 34).

Water Quality

— Most of the public water supplies provide a water that meets the "Acceptable" limits of the Guidelines, most of the time. . . . Very few achieve the "Objective" limits of these Guidelines (page 40).

— In the last 10 years, improvements have been made to severely oxygen depleted rivers, particularly those affected by pulp mills and municipal sewage (page 44).

— . . . current farming practices are the major contributors to a siltation problem which is increasing every year. . . . Soil erosion rates in New Brunswick have increased by over 5 times since 1945 . . . (page 45).

— While many small communities have sewage treatment systems, many larger centers, including Halifax, Dartmouth, Sydney, Edmundston and St. John's do not (page 48).

— Between 1972 and 1982 point source pollution (on the Saint John River) was reduced by 88% in terms of biological oxygen demand (BOD) loading, and by 82% in terms of suspended solids discharged (page 49).

— The improved oxygen regime (on the St. Croix River) is now such that the river is capable of supporting an anadromous run of Atlantic salmon (page 50).

— Although many potential sources of groundwater contamination have been identified in the Atlantic region, the limited data base does not permit an accurate estimate of the magnitude of the problem or the most important sources (page 57).

— For the pulp and paper industry . . . in the Atlantic region, . . . approximately 60% reductions in BOD and 51% reductions in SS were realized in the period 1969-1984 (page 59).

— Results to date indicate that there is no discernible impact from the operation of the (Point Lepreau nuclear generating) plant (page 66).

— DFO responded to (the discovery of PAH contamination in Sydney Harbour) in 1982 with a lobster fishing ban in the South Arm . . . (page 67).

— Despite substantial improvements in the quality of (base metal mine) effluents, . . . most of the mines still exceed the Metal Mining Liquid Effluent Guidelines (page 70).

— The high concentration of cadmium in resident lobster muscle and tomalley (in Belledune Harbour) have made them unsafe for human consumption . . . DFO closed the harbour to lobster fishing in 1980, . . . (however) conditions have improved to the extent that the lobster fishery . . . was reopened in 1985, under controlled marketing conditions (page 74).

— As of 1983, there were 262 shellfish growing areas in the Maritime Provinces closed to harvesting (25 of these closed since 1979), comprising a total surface area of approximately 140,000 ha (page 76).

— It has been estimated that about 80% of all marshlands in the Maritimes have been reclaimed at one time . . . leaving only 20,000 hectares of natural salt marshes in the 3 Maritime Provinces (page 80).

— (In Saint John Harbour), . . . it is the cumulative impacts of the many development activities in the harbour and along the Saint John River that have had an incremental effect on the fish stocks and landings in the area (page 81).

— Background levels of petroleum hydrocarbons throughout the Northwest Atlantic are well below those known to have adverse acute effects on most marine life, (and) . . . seem to be below those that have been demonstrated to have low-level, long term effects. Recent data also confirm a decline in the background levels . . . throughout the 1970s (page 84).

— This is the first clear indication that DDT group residues in high trophic level marine biota have responded to the DDT ban of the early 1970s (page 87).

Toxic Chemicals

— . . . although pockets of (cadmium) contamination occur in the Atlantic region, ambient concentrations are of the magnitude where widespread lethal or sub-lethal effects are unlikely (page 100).

— PCBs are distributed in the environment throughout the Atlantic region, but more serious contamination is restricted to several specific locations throughout the region (page 104).

— The use of herbicides in the forest industry has received considerable public attention in the Atlantic region (page 108).

— Agricultural lands in Canada currently receive 15 times more insecticide than forests (page 113).

— An estimated 131,700 tonnes of hazardous wastes are generated annually in the Atlantic region, . . . 5% of the Canadian total (page 116).

— There is as yet no systematic or comprehensive approach to the problem of hazardous waste management in the Atlantic region. Disposal is handled on a case-by-case basis, often employing undesirable practices (page 117).

— By the end of 1984, 782 active and 752 inactive waste disposal sites were located in the Atlantic region. There are undoubtedly many more which remain to be discovered. Only 5 of these sites are considered to be properly run landfills . . . (page 119).

Other Environmental Issues

— The 300 year history of forest exploitation, an increase in the incidence of fire, and major losses by disease and insects have had a profound effect on the forest (page 129).

— While insecticides such as fenitrothion and aminocarb have reduced budworm damage in New Brunswick, they have also had the unfortunate effect of prolonging the epidemic (page 133).

— New (coal) combustion technlogies are being tested (in the region which) . . . will substantially reduce SO_2 *and* NO_x *emissions from coal-fired plants (page 140).*

— The Charlottetown, P.E.I. (municipal waste incinerator) plant, operational in February 1983, displaces more than 20,000 barrels of imported oil per year (page 145).

Human Health in the Environment

— . . . (In Labrador city), a one year community air quality study in 1980 found no evidence that the general respiratory health of the residents . . . has been affected by mining, processing or waste disposal operations (page 161).

— An association has been demonstrated between higher rates of neural tube defects . . . and potential agricultural chemical exposure, which appears to be concentrated within the prime agricultural areas of the Saint John river valley and northern New Brunswick counties (page 163).

— Arsenic contamination of wells in several communities in Halifax county has been documented over the last decade, with many water samples exceeding the maximum acceptable drinking water guideline of 50 ng As/ml (page 164).

— There have been no major outbreaks of intestinal diseases attributed to shellfish harvested from approved growing areas since (1972) (page 165).

Nature Conservation

— The year 1985 marked the National Parks Centennial . . . (page 168).

— In 1983, 4,460,000 people visited the 7 Atlantic national parks, a 19.4% increase over the number of visitors in 1978 (page 169).

— Since (1966), 8,194 ha of important wildlife habitat have been acquired at 12 sites in the Atlantic region. Most areas are wetlands of considerable importance to waterfowl . . . (page 171).

— With few exceptions, the majority of (Atlantic region ecological reserve) sites located outside national parks still lack adequate protection . . . (page 176).

— Unlike national parks, most provincial parks in (the Atlantic Provinces) . . . incorporate tourism, recreation, and economic benefits to the province as critical factors in their development (page 178).

Developments in Environmental Management

— Seven proposals in the Atlantic region have been referred to FEARO for formal EA Panel reviews since 1974 (page 188).

— . . . there has been little or no formal follow-up of completed projects in the Atlantic region (page 192).

— The Atlantic Region Pesticides Advisory Committee (ARPAC) has been established among federal agencies in the region to provide advice to provincial and federal agencies on pesticide applications. ARPAC is unique to the Atlantic region . . . (page 197).

— The past five years have demonstrated a significant trend of increasing regional concern over hazardous wastes, particularly on the part of provincial governments (page 198).

— Exploration for oil and gas off the Canadian east coast began in the Sable Island area in 1959, and on the Grand Banks in 1964. Since then, approximately 200 wells have been drilled . . . (page 200).

— . . . the Uniacke G-72 well released an estimated 1.9 to 2.4 million cubic metres of gas and 23.4 cubic metres (150 barrels) of condensate per day during an 11 day blowout (page 202).

— An estimated 1.4 million litres (1,200 tonnes) of oil are discharged per year from bilges and tank cleaning operations off Atlantic Canada . . . These discharges are a threat to seabird populations . . . (page 203).

— Approximately 1 (oil) polluting vessel is sighted per week off the east coast (page 207).

— Much of the material (ocean) dumped in the Atlantic region (approximately 90%) is clean dredged material, but there are situations where contaminated dredged materials are involved. In some of these cases it has been necessary to develop alternative methods of disposal (page 209).

Trends in Environmental Research

— Air pollution was, until the late 1970s, thought to be a problem of only local magnitude. In 1979, . . . (a) joint Canada—U.S. working group . . . identified acidic precipitation as the "problem of greatest common concern at the present time" (page 212).

— Water quality research has changed its focus from wide regional surveys, and nutrient and BOD monitoring in the 1960s and early 1970s to trend assessments and toxic contaminants (page 212).

— The bioavailability of toxic organic substances (in the marine environment) has been the focus of recent research (page 214).

— Pesticide research is very active in the Atlantic region (page 215).

Chapter 1
Air Quality

Summary

The air in many cities in Atlantic Canada is cleaner now than it was five years ago. Efforts to control air pollution have resulted in reduced levels of SO_2, NO_X, suspended particulate matter (SPM) and lead in urban air. The same is not true, however, for ozone which is mostly imported into the region and beyond our immediate control. Ambient air concentrations remain mostly within acceptable air quality objectives and Canadian and American national averages.

Although urban concentrations of SO_2 and NO_X are within the acceptable range of values, these pollutants continue to create problems as major contributors to acid rain, a problem very keenly felt in Atlantic Canada.

The most serious local air quality problem in this region exists in the vicinity of the Sysco steel plant at Sydney, N.S. Although levels of SPM there have been reduced in recent years, they remain consistently above the acceptable objective and both national averages. Levels of polycyclic aromatic hydrocarbons (PAHs) in the residential areas adjacent to the coke ovens have been some of the highest in North America, even with the coke ovens operating at less than 50% of capacity. The coke ovens were shut down in December, 1983, but reopened in December, 1985, without pollution controls.

Other industrial point source emissions have been consistently reduced over the last five years. This is true for emissions of asbestos and fluoride in Newfoundland and for mercury from the region's two chlor-alkali plants, which have been in compliance with the federal regulations since 1979. Nevertheless, with the natural mercury content of local coals and their increased use in thermal generating stations, this may now represent the major source of atmospheric mercury emissions in the region.

1.0 AIR QUALITY

The Clean Air Act provides the basis for the federal government's air pollution control activities. Its primary objective is to protect the health of the public of Canada from air pollution[1]. A prerequisite to an effective air pollution control program is an accurate understanding of the problem. Such an understanding is gained by determining the sources and magnitude of emissions and by measuring the concentrations of contaminants in the ambient air. Emission inventories are maintained for the major point and non-point (area) sources in the Atlantic Provinces and federal and provincial ambient air monitoring networks are set up in the major urban centres of the region.

Monitoring efforts have traditionally focussed on the "conventional" air pollutants: total suspended particulates (TSP), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), carbon monoxide (CO), ozone (O_3) and lead (Pb). These air pollutants are generated by a number of sources and are often a problem in major urban areas. Tables 1, 4, 5, 6 and 7 and Figures 2, 4, 6, 8 and 10 outline the major point and non-point sources in the Atlantic region.

"Hazardous" air pollutants, on the other hand, are usually local problems typically found in the vicinity of specific industrial sources (e.g. mercury is a hazardous air pollutant emitted from chlor-alkali plants). Federal regulations limiting the emissions of hazardous air pollutants from specific industrial sectors have been published for lead, mercury, vinyl chloride, asbestos and arsenic (See section 1.2).

National Air Quality Objectives (NAQOs) have been published for the five substances collectively called the "conventional" air pollutants. Within the NAQOs, three levels of air quality are recognized: "desirable", "acceptable" and "tolerable". The "desirable" level is a long-term goal and forms the basis for protection of pristine areas of the country. The "acceptable" level is intended to provide adequate protection against effects on soil, water, vegetation, materials, animals, visibility, personal comfort and well-being (i.e. the most sensitive receptors in the environment). When concentrations of air contaminants exceed the "tolerable" level, the health of the general population could be threatened and immediate control action is warranted[1].

The concentrations of conventional contaminants in the ambient air are measured by the National Air Pollution Surveillance (NAPS) network. NAPS is a joint federal and provincial project, the purpose of which is to monitor and assess, on a continuing basis, the quality of the ambient air in the urban regions of Canada. Over time, it has been possible to detect pollution trends with respect to changing industrial activity and population density, as well as progress in air pollution abatement measures.

Measurements are being made for SO_2, CO, NO_2, O_3, suspended particulates, lead, dustfall, soiling index, and sulphation rate[2]. (At present, there is insufficient data available in the region to discuss trends in the soiling index, dustfall and sulphation rates).

The NAPS network in the Atlantic Provinces consists of 5 sites in Halifax/Dartmouth, N.S., 2 in Sydney, N.S, and 1 in each of Saint John, N.B., St. John's, Nfld., Charlottetown, P.E.I., Glace Bay, N.S., and Fredericton, N.B. Not all substances are measured at each site and there are no NAPS stations located outside urban centres. In many areas, the NAPS network forms the backbone for large provincial air monitoring networks.

Air quality is measured by comparing ambient air pollution with the appropriate NAQO. Data being considered in this report cover the 10 year period 1974 to 1983. For each parameter the "worst", "middle case" and "best" stations (as compared to the objectives) are presented in Figures 3, 5, 7, 9 and 11.

Monitoring data include ambient values measured at individual sampling sites within a city but figures may not necessarily represent community-wide air quality[2]. Similarly, individuals may be subjected to quite different exposures in the short or long-term (e.g., from the exhaust fumes from the car in front of a driver in heavy traffic or the conditions in the immediate vicinity of a thermal generating station).

There are other locations within the Atlantic region which may have decreased air quality, but which do not have NAPS monitoring stations. These are usually associated with oil refineries, pulp and paper mills, smelters, thermal generating stations, and other emission sources.

Provincial monitoring networks have been established in the vicinity of Dalhousie, N.B. (SO_2), Belledune, N.B. (SO_2, TSP and metals), Saint John, N.B. (SO_2, TSP, NO_2, O_3), Edmundston, N.B. (SO_2), the Sydney, N.S. area (SO_2, TSP, NO_2), Canso, N.S. (SO_2, TSP, H_2S), Grand Falls, Nfld. (SO_2), Corner Brook, Nfld. (SO_2), Labrador City (TSP) and Holyrood, Nfld. (SO_2, TSP).

1.1 Conventional Air Pollutants

1.1.1 Total Suspended Particulates

Total suspended particulate (TSP) is a general term applied to a wide variety of solid or liquid particles of a size and configuration which tend to remain airborne and a portion of which can be drawn deep into the respiratory tract[3]. TSP is a measure of suspended particulates in the ambient air, ranging up to 25-45 microns in diameter[4]. Particulate matter is the most commonly perceived form of air pollution, often manifesting itself by impairment of visibility, soiling of materials and irritation of the respiratory system. Ambient air quality objectives have been established with the goal of minimizing these undesirable effects[3].

In the Atlantic region, the more important point sources of TSP (as recorded in 1980) include: the iron ore mining and milling operations in western Labrador, the Sydney steel mill, thermal generating stations, pulp and paper mills, asbestos mining/milling (Baie Verte, Nfld.), phosphorus production (Long Harbour, Nfld.) and lime works. The location and magnitude of these point sources is shown in Figure 2. Recent data indicate that the magnitude of most of these emissions has decreased since 1980. (A comprehensive data base has not yet been compiled). Dust emissions from construction sites, roads, mining and rock quarrying, as well as slash burning, fuelwood combustion, agriculture and asphalt production are important area, or non-point sources of particulates in this region (Table 1).

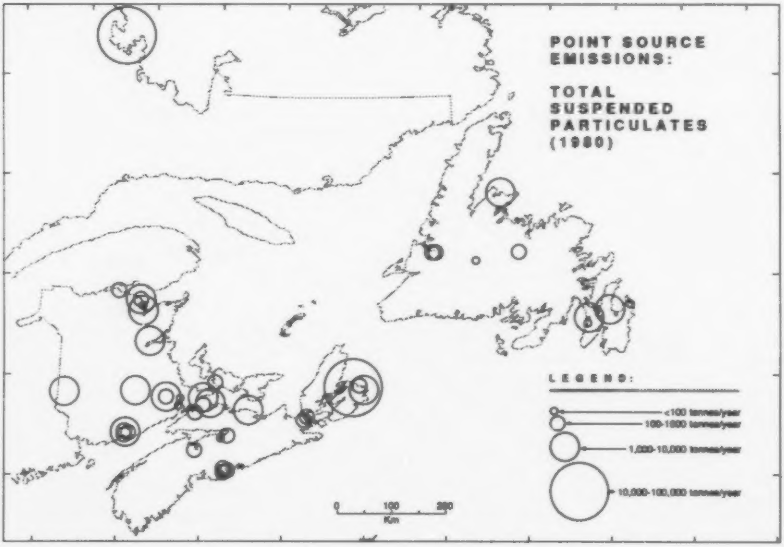

POINT SOURCE EMISSIONS:
TOTAL SUSPENDED PARTICULATES (1980)
LEGEND:
<100 tonnes/year
100-1000 tonnes/year
1,000-10,000 tonnes/year
10,000-100,000 tonnes/year
0
100
200
Km

Figure 2 Point source emissions of total suspended particulates (TSP) in the Atlantic region (1980)[5]

TSP is monitored at 11 NAPS stations in the Atlantic region: 4 in Halifax, N.S., 2 in Sydney, N.S., and 1 in each of St. John's, Nfld., Charlottetown, P.E.I., Glace Bay, N.S., and Fredericton and Saint John, N.B. Provincial environment departments and some industries also operate permanent TSP monitors. In many cases, in the past, there were insufficient data collected to calculate a valid mean, thus the calculation of a percentage decrease for TSP in the Region was not possible. Nevertheless, some trends are apparent.

TABLE 1
Estimates of Non-Point Source Emissions of Particulates in the Atlantic Region (1980) (tonnes/year)

Source	N.S.	N.B.	P.E.I.	Nfld.	Atlantic Region
Construction Sites	276,622	427,407	54,176	191,507	949,712
Dust from Unpaved Roads	431,728	232,559	24,072	141,821	830,180
Dust from Paved Roads	34,754	31,091	5,543	17,762	89,150
Mining & Rock Quarrying	4,205	9,549	—	10,921	24,675
Slash Burning	5,947	10,977	364	3,658	20,946
Fuelwood Combustion	7,422	4,622	1,559	7,006	20,609
Agriculture	5,437	6,551	7,118	77	19,183
Asphalt Production	2,882	4,600	1,148	1,054	9,684
Forest Fires	1,572	4,645	111	1,574	7,902
Industrial Fuel Combustion	1,354	2,456	38	1,972	5,820
Gasoline-powered Motor Vehicles	1,778	1,195	231	799	4,003
Stone Processing	1,033	1,560	—	345	2,938
Diesel-powered Engines	1,029	771	138	886	2,824
Wood Industry	464	1,532	3	23	2,022
Tailings Piles	64	560	—	1,038	1,662
Sand & Gravel Processing	575	440	60	550	1,625
Commercial Fuel Combustion	584	472	133	158	1,347
Solid Waste Incineration	338	657	30	94	1,119
Residential Fuel Combustion	651	202	36	125	1,014
Off-Highway Mobile Sources	294	198	19	322	833
Coal Mining & Transport	274	379	—	—	653
Clay Products Manufacturing	423	168	—	61	652
Cigarette Smoking	169	139	24	113	445
Structural Fires	210	136	21	65	432
Pesticide Application	72	152	195	3	422
Grain Handling & Milling	245	146	—	—	391
Fertilizer Application	72	115	116	10	313
Tire Wear	134	90	18	55	297
Electric Power Generation	9	8	—	157	174
Ferrous Foundries	144	14	4	—	162
Concrete Batching	44	43	5	38	130
Non-Highway Use of Gasoline	10	49	12	6	77
TOTALS	780,539	743,483	95,174	382,200	2,001,396

Source: Environment Canada. EPS, 1982[5].

On a national scale, the overall average of the annual geometric means decreased approximately 20% between 1974 and 1981 and mean values have levelled off in the 50-60 μg/m³ range in recent years[3]. Annual average TSP levels in the U.S. decreased 15% between 1975 and 1982 to the same general range of values[4]. In the Atlantic Provinces, TSP levels generally declined between 1974 and 1983. Data from Halifax and Fredericton show no change over time, while St. John's and Charlottetown show declining levels. Levels in all four cities are consistently below both the Canadian and American national averages and within the desirable objective. Stations in Saint John, Sydney (County Jail Station) and Glace Bay record levels and trends similar to the national averages. Only one station in Sydney, N.S. (next to the steel plant) records levels consistently and significantly above the acceptable objective and national averages. In fact, it records some of the highest levels of TSP in the country.

Figure 3 shows the trends for the "best" "middle" and "worst case" stations in the region, in comparison with the Canadian and U.S. national averages. The graphical presentation of the data clearly shows that although the mean values are mostly below the "acceptable" objective, many of the recorded values frequently exceed the objective limits for short periods of time. This will be obvious for most of the ambient air quality parameters.

The major point source of suspended particulate matter in this region is the iron ore mining and concentrating operations in Labrador City and Wabush in western Labrador. Both operations involve open pit mining, ore concentration and transportation of products. Virtually every material handling and most processing operations generate dust. Resuspension of dust from mine roads and dry exposed tailings is another potentially significant source of particulate matter. The combined annual dust emissions from the two facilities were estimated at approximately 65,000 tonnes in 1980. Some improvement has been realized, although not quantified, due to concerted efforts in tailings vegetation at the Wabush mine and road paving around the milling operation in Labrador City.

Short-term air quality in these communities, as measured by 24-hour suspended particulate data, has on occasion exceeded the Newfoundland air quality regulations: however, long-term air quality, as measured by annual suspended particulate levels, does meet provincial requirements. In Labrador City, process sources represent the largest single factor in exceedences of the 24-hour provincial regulation for TSP, although wind blown tailings are more significant in many of the worst episodes and constitute the predominant contribution to the fine, inhalable size fraction. Resuspended road dust is also a sizable contributor in Labrador City and significantly influences such exceedences in Wabush[6]. Although occupational exposures have resulted in several cases of dust related lung disease in the work force over the years, there is no evidence that the general respiratory health of the residents of Labrador City and Wabush has been affected[7]. (See also the section on Human Health and the Environment).

Another major point source of TSP in this region is the Sysco steel plant in Sydney, N.S., which emitted about 20,000 tonnes in 1980. The open hearth furnaces there account for over 71% of the emissions,

SUSPENDED PARTICULATE MATTER

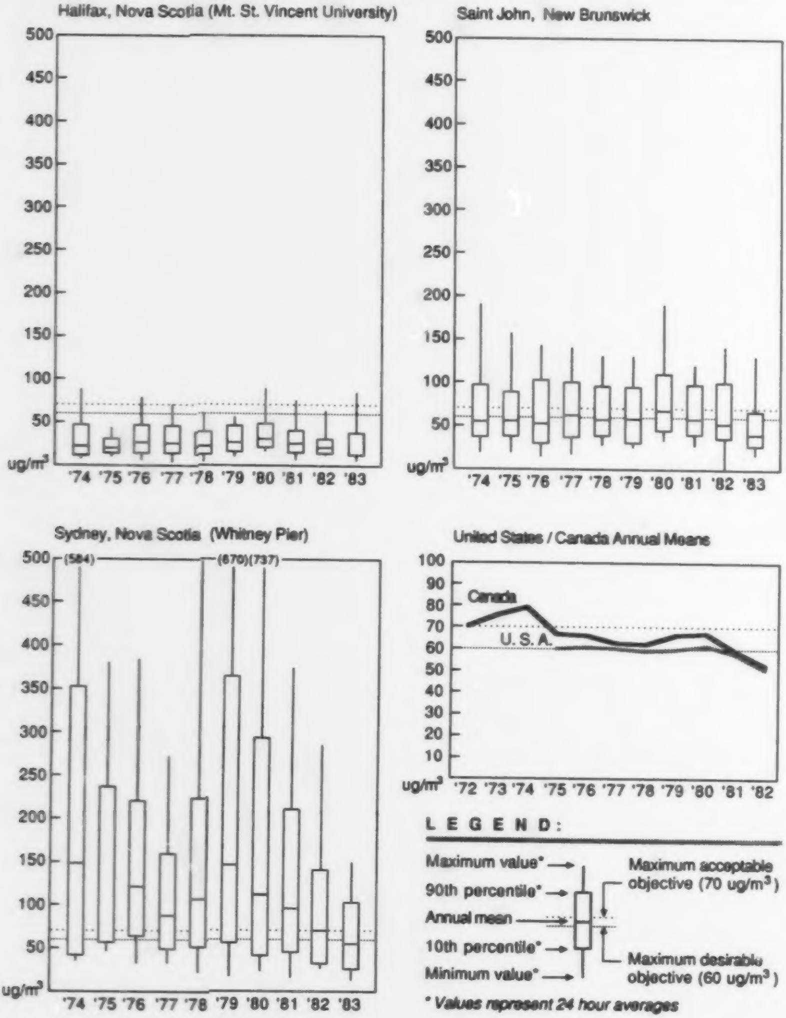


Figure 3 Ambient air monitoring trends for total suspended particulates (TSP) in Atlantic region cities (1974-1983)[2]

while the blast furnaces contribute about 18% of the total particulate emissions. The remaining emissions are attributed to the coke ovens and several smaller sources at the complex. A combination of installed air pollution controls on the blast furnace and a reduced operating capacity has resulted in reduced TSP emissions from the mill (6,000 tonnes in 1982).

Grain handling, although only a minor source of particulates on a regional basis (Table 1), has created localized nuisance problems at a facility in Halifax. In response to complaints of residents in the vicinity of the facility, air pollution controls were installed in 1984, thereby significantly decreasing dust emissions in neighbourhood residential areas.

Another long-standing nuisance problem has been the localized soot fallout from the Tufts Cove generating station in Dartmouth, N.S. The Nova Scotia Power Corporation is presently installing a control device to reduce this fallout to near zero. Similar complaints are commonly received from residents in Grand Falls and Corner Brook, Nfld., due to emissions from the waste boilers at the pulp mills situated there. These problems are gradually being alleviated.

1.1.1.1 Polycyclic Aromatic Hydrocarbons (PAHs)

Since the late 1970s, a greater concern has been placed on the emissions of polycyclic aromatic hydrocarbons (PAHs) from the coke ovens at Sysco. (PAHs are listed as hazardous pollutants by the United States Environmental Protection Agency). Although the coke ovens were shut down from December 1983 to December 1985, an ambient air study conducted in Sydney from October 1981 to September 1982 indicated that levels of benzo[a] pyrene (BaP) (which has been shown to be carcinogenic, mutagenic and/ or cocarcinogenic in animals) and other PAHs were highest near the coke ovens, confirming that they were the source of the elevated levels of PAH in the area[8]. The average BaP level measured in Sydney at a site near the coke ovens (3.74 ng/m^3) was higher than the average obtained from heavily industrialized cities with coke ovens such as Hamilton, Ontario (2.30 ng/m^3) and certain U.S. cities (1.21 ng/m^3). Further, the study results are considered to be on the conservative side, since the coke ovens were operating at less than 50% of design capacity at the time the study was conducted. A control site in Sydney (St. Rita's Hospital) located 4 kms upwind from the coke ovens is representative of background levels in Sydney (0.23 ng/m^3) and compares favourably with other studies in rural and urban areas of North America (Table 2). EPS has recommended that the health implications of such levels should be investigated. (See also the section on Human Health and the Environment).

TABLE 2
Comparison of BaP and Total PAH Values in Ambient Air

Location	BaP (ng/m³) Average	BaP (ng/m³) Range	PAH (ng/m³) Average	PAH (ng/m³) Range
Sydney				
Frederick St. (450 m downwind of coke ovens)	3.74	0.06 — 21.14	36.56	0.69 — 201.56
County Jail (750 m upwind of coke ovens)	1.74	0.02 — 36.42	31.16	0.36 — 622.40
St. Rita's Hospital (control) (4 km upwind of coke ovens)	0.23	N.D. — 1.98	3.48	0.09 — 23.70
Sydney (average)	1.90	0.23 — 3.74	—	—
Hamilton, Ontario *with* coke ovens	2.30	1.40 — 3.50	18.67	9.85 — 32.15
Sudbury, Ontario	0.27	0.11 — 0.44	3.16	1.66 — 5.17
Sarnia, Ontario	0.31	0.11 — 0.60	3.42	1.71 — 6.12
Toronto, Ontario (downtown)	0.65	0.41 — 0.81	9.96	5.50 — 17.49
Toronto, Ontario (downtown-heavy motor vehicle traffic)	1.06	0.72 — 1.67	11.05	7.86 — 17.36
U.S.A. National Average *with* coke ovens (1975)	1.21	0.30 — 4.70		
U.S.A. National Average *without* coke ovens (1975)	0.38	0.30 — 0.90		
U.S.A. National Average — rural areas	0.10			

Source: Atwell *et al.*, 1984[8].

Residential wood combustion emits similar quantities of particulates, but from many smaller sources. Over the last few years residential wood heating has increased rapidly in the Atlantic region as a result of increased energy costs. A recent marketing study estimated that approximately one-third of the households in the Maritime Provinces are active wood burners[10]. There was a more than 10% increase in fuelwood production in the Atlantic region between 1980 and 1981 (including a 70% increase in P.E.I.). A 16% increase was recorded for the whole of Canada[10]. (See section 4.2.3.1).

Wood stoves can be substantial emitters of particulates, carbon monoxide and a wide variety of organic compounds if not properly operated. More than 20,000 tonnes/year of particulates were emitted from residential fuelwood combustion in the Maritimes in 1980 (Table 1) and emissions are expected to have increased since then. Studies in the U.S. indicate that these particulate emissions are almost entirely in the inhalable size range and contain toxic and carcinogenic pollutants such as BaP. The use of residential wood stoves is not only increasing overall, but significant increases are occurring in urban areas relative to rural locations. Very localized impacts may be magnified, because such emissions are released close to the ground and may remain trapped there under certain local meteorological conditions.

In response to increasing complaints in Nova Scotia and New Brunswick regarding emissions from wood stoves, the federal and provincial Departments of the Environment conducted air quality studies in the winters of 1984 and 1985 in Truro and Lower Sackville, N.S. and Fredericton, N.B., where wood stove use is estimated at approximately 45% of households. Results to date indicate that residential wood combustion may add 10 to 20 $\mu g/m^3$ to the average TSP levels, but could make a much higher contribution on individual days under certain weather conditions such as a thermal inversion. Average TSP levels (with the range of geometric means from all studies being 12.6-33.0 $\mu g/m^3$) are well below the maximum desirable objective of 60 $\mu g/m^3$ and lower than the mean TSP values recorded in the larger urban centres in this region. (See Figure 3). Elevated TSP levels in Lower Sackville and Fredericton may, nevertheless, result in localized nuisance problems such as odours, visibility reduction, soiling and respiratory discomfort for some residents[9]. Available PAH data for these places does not suggest a public health impact, as levels are relatively low in comparison to other areas (Table 3). (See also the section on Human Health and the Environment).

TABLE 3

Comparison of BaP and Total PAH Results Measured in Lower Sackville and Truro, N.S. in 1984 with Data from Other Studies

Location	BaP (ng/m^3)		PAH (ng/m^3)	
	Average	Range	Average	Range
Truro, N.S.	0.33	N.D. — 1.04	5.22	0.12 — 17.80
Lower Sackville, N.S.	0.34	N.D. — 1.66	6.34	0.114 — 29.80
Frederick St., Sydney, N.S. (close to coke ovens)	3.74	0.06 — 21.14	36.56	0.69 — 201.56
St. Rita's Hospital, Sydney, N.S. (control site)	0.23	N.D. — 1.98	3.48	0.09 — 23.70
Hamilton, Ontario *with* coke ovens	2.30	1.40 — 3.50	18.67	9.85 — 32.15
Whitehorse, Yukon (Stn. 1)•	9.80	1.20 — 30.60	364.20	31.60 — 1950.00
Whitehorse, Yukon (Stn. 2)•	15.80	6.70 — 50.60	729.80	181.00 — 2530.00
Whitehorse, Yukon (Stn. 3)•	15.30	0.96 — 44.70	700.90	11.80 — 2241.00

•Heavy wood stove use and emissions commonly trapped close to ground due to meteorological conditions.

Source: Kozak, 1985[9].

1.1.2 Sulphur Dioxide (SO_2)

There are two components to the issue of SO_2 in the Atlantic region. There is the 75-80% contribution of sulphur deposited here from central Canada and the northeastern U.S.[11], and the locally generated SO_2, the major source of which is the thermal generating stations. The "imported" SO_2 is a major component of the acid rain problem (and is discussed in section 1.3), while the regionally produced SO_2 and its implications are discussed below.

Thermal generating stations in New Brunswick and Nova Scotia emit nearly 87% of the total SO_2 produced within the region[12]. In 1983, stations in Nova Scotia and New Brunswick emitted 121,000 and 111,000 tonnes of SO_2 respectively. Figure 4 identifies the location and magnitude of the regional point sources. Industrial, commercial, and residential fuel combustion, and motor vehicles contribute the majority (90%) of the remaining non-point source SO_2 (Table 4).

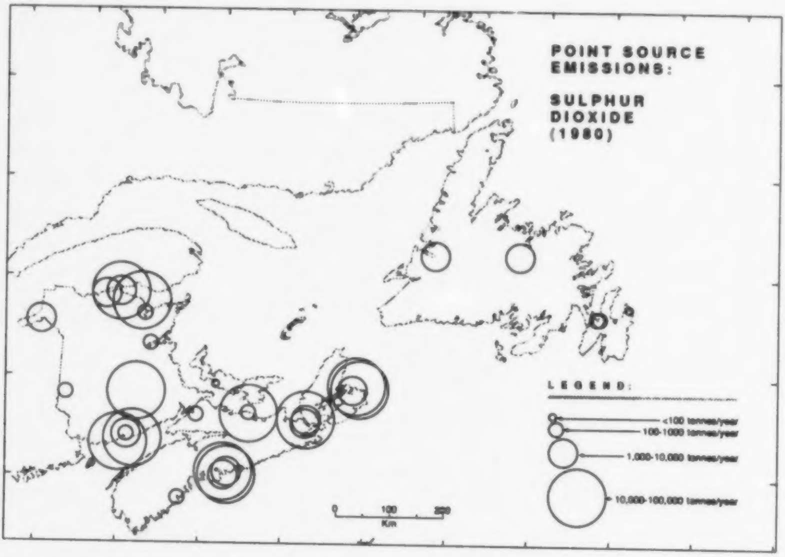

POINT SOURCE EMISSIONS:
SULPHUR DIOXIDE (1980)
LEGEND:
<100 tonnes/year
100-1000 tonnes/year
1,000-10,000 tonnes/year
10,000-100,000 tonnes/year
0
100
200
Km

Figure 4 Point source emissions of sulphur dioxide (SO_2) in the Atlantic region (1980)[5]

Local emissions can increase sulphur deposition within 50 km of the emission sources. Approximately 61% of the total sulphur deposited at a rural site 25 km west of Halifax was from emission sources in the Halifax/ Dartmouth area[13].

Nova Scotia and New Brunswick are both expected to increase their respective coal-fired generating capacity in the next decade. Maritime coals have a relatively high sulphur content compared to other Canadian coals, ranging between 5% and 8% for New Brunswick coals and 1% to 5% for Nova Scotia coals[12]. An important consideration in this shift in fuel source is that a megawatt of power produced from a 3% sulphur coal will result in approximately 50% higher SO_2 emissions than from burning a 3% sulphur oil[14].

TABLE 4

Estimates of Non-Point Source Emissions of Sulphur Dioxide (SO_2) in the Atlantic Region (1980) (tonnes/year)

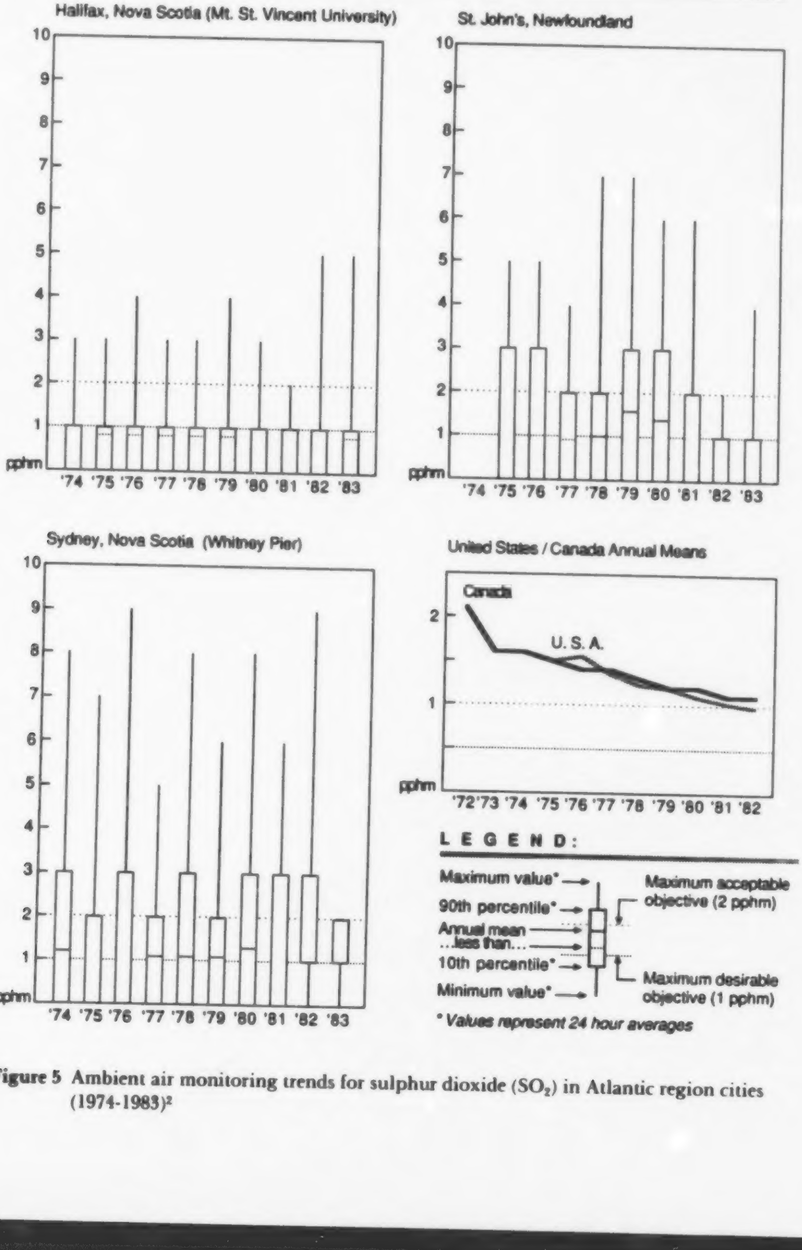
Source	N.S.	N.B.	P.E.I.	Nfld.	Atlantic Region
Industrial Fuel Combustion	16,988	29,335	518	26,547	73,388
Commercial Fuel Combustion	8,231	6,949	475	2,454	18,109
Residential Fuel Combustion	7,140	3,567	646	1,824	13,177
Off-Highway Mobile Sources	1,730	1,138	78	1,074	4,020
Diesel-powered Engines	1,588	1,106	209	1,085	3,988
Gasoline-powered Motor Vehicles	802	533	106	331	1,772
Fuelwood Combustion	143	137	—	207	487
Electric Power Generation*	14	59	—	262	335
Mining & Rock Quarrying	7	115	—	26	148
Solid Waste Incineration	26	23	2	12	63
Non-Highway Use of Gasoline	7	37	9	5	58
TOTALS	36,676	42,999	2,043	33,827	115,545

*NOTE: does not include thermal generating stations.
Source: Environment Canada. EPS, 1982[5].

The extent of the increase in SO_2 emissions in both provinces will depend largely on the natural sulphur content of the thermal coal used, the degree of coal-cleaning employed and the generation mix employed by Power Corporations. While Nova Scotia is committed to the increased use of local coal, New Brunswick places more emphasis on a mix of coal and oil-fired thermal generating stations, hydroelectric developments, out-of-province purchases of power and, since 1983, a nuclear power plant (the last three producing no SO_2 emissions). As a result, SO_2 emissions in Nova Scotia are expected to rise in the next few years[14], while those in New Brunswick should fall from present levels[15].

Ambient SO_2 is monitored at 9 NAPS stations in the region: 3 in Halifax, N.S., 2 in Sydney, N.S., and 1 in each of St. John's, Nfld., Charlottetown, P.E.I., Glace Bay, N.S., and Saint John, N.B. Although the data is incomplete for most stations, it is obvious that the mean ambient SO_2 levels in the urban centres of the Atlantic region consistently ranged between the maximum desirable — 1.0 parts per hundred million (pphm) — and acceptable (2.0 pphm) objectives in the period 1974 to 1983 (Figure 5). Trends are difficult to discern but reductions are noted in Halifax (downtown) and Saint John, N.B. On a national scale, the average of the annual arithmetic means decreased from around 1.5 to 1.0 pphm, consistently below the maximum acceptable level[3]. Annual average SO_2

SULPHUR DIOXIDE


Halifax, Nova Scotia (Mt. St. Vincent University)

St. John's, Newfoundland

Sydney, Nova Scotia (Whitney Pier)

United States / Canada Annual Means

Figure 5 Ambient air monitoring trends for sulphur dioxide (SO_2) in Atlantic region cities (1974-1983)[2]

levels in the U.S. decreased 33% from 1975 to 1982 to the same levels (around 1.0 pphm)[4].

1.1.3 Nitrogen Dioxide (NO_2)

Gasoline-powered motor vehicles are the predominant source of nitrogen dioxide. Other significant non-point sources in the Atlantic region include diesel engines, industrial fuel combustion, power plants, fuelwood combustion, and residential and commercial fuel combustion (Table 5). Thermal generating stations, oil refineries and pulp mills are the major point sources in the region (Figure 6).

TABLE 5

Estimates of Non-Point Source Emissions of Nitrogen Dioxide (NO_2) in the Atlantic Region (1980) (tonnes/year)

Source	N.S.	N.B.	P.E.I.	Nfld.	Atlantic Region
Gasoline-powered Motor Vehicles	18,266	12,139	2,406	7,520	40,331
Diesel-powered Engines	11,299	8,593	1,375	10,975	32,242
Industrial Fuel Combustion	2,444	4,489	85	3,761	10,779
Off-Highway Mobile Sources	4,471	2,275	282	3,226	10,254
Fuelwood Combustion	6,464	276	93	418	7,251
Residential Fuel Combustion	2,177	1,415	275	795	4,662
Commercial Fuel Combustion	1,457	1,234	171	601	3,463
Electric Power Generation	98	108	—	1,724	1,930
Slash Burning	529	976	32	325	1,862
Non-Highway Use of Gasoline	159	794	197	97	1,247
Forest Fires	42	124	3	42	211
Solid Waste Incineration	51	76	5	19	151
TOTALS	47,457	32,499	4,924	29,503	114,383

Source: Environment Canada. EPS, 1982[5].

Although the objectives for this contaminant were established to prevent adverse human health effects and plant damage, the major role of nitrogen oxides in atmospheric photochemical reactions is also recognized, (see section 1.1.5 on Ozone), as is their significant contribution to the acid rain phenomenon[5]. (See section 1.3 on Acid Rain).

Ambient NO_2 levels are measured at 3 stations in the Atlantic region: 2 in Halifax/Dartmouth and 1 in Saint John, N.B. (Figure 7). The downtown Halifax station recorded the highest levels, but these were consistently below the maximum acceptable objective. Significant trends are not apparent, although there may have been a slight decline in ambient levels since 1981. On a national scale, the average NO_2 annual mean has not exceeded the maximum desirable level since 1977. Furthermore, the decline in the percentage of stations meeting or exceeding the annual air quality objectives each year show that some improvement in air quality with respect to NO_2 has been achieved[3]. In the U.S., there has been no long-term change in ambient NO_2 levels[4]. Atlantic region stations have been recording slightly lower ambient levels in recent years than the rest of Canada and the United States (where levels range between 2.2 and 3.1 pphm).

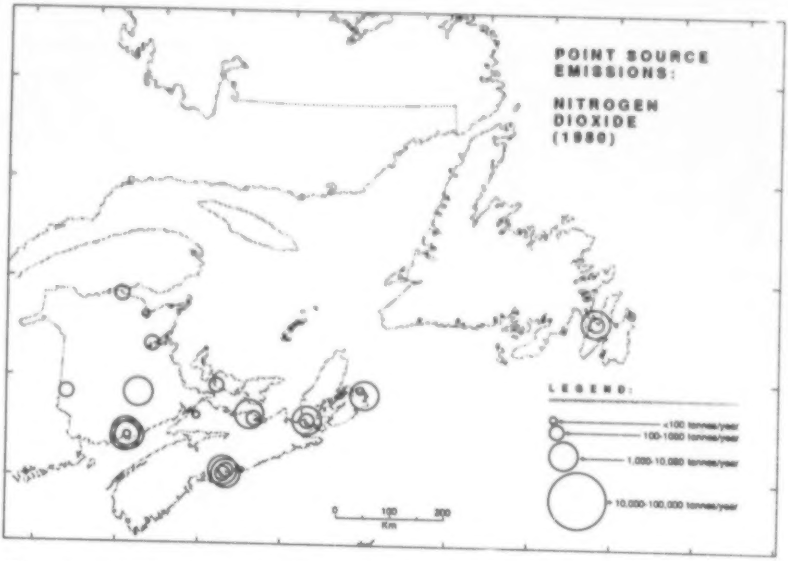

POINT SOURCE EMISSIONS:
NITROGEN DIOXIDE (1980)
LEGEND:
<100 tonnes/year
100-1000 tonnes/year
1,000-10,000 tonnes/year
10,000-100,000 tonnes/year
0
100
200
Km

Figure 6 Point source emissions of nitrogen dioxide (NO_2) in the Atlantic region (1980)[5]

1.1.4 Carbon Monoxide (CO)

Carbon monoxide is produced by the incomplete combustion of organic fuels. The major source of CO emissions is gasoline-powered vehicles. Other important non-point sources in the Atlantic region include slash burning, fuelwood burning, the non-highway use of gasoline, and solid waste incineration (Table 6). Oil refineries, thermal generating stations and pulp mills account for the majority of the point source emissions (Figure 8). Ambient air quality objectives for this pollutant are concerned with the prevention of chronic health effects in humans[3].

Carbon monoxide is monitored at only 3 stations in the Atlantic region: St. John's, Nfld., Halifax, N.S. (downtown), and Saint John, N.B. (Figure 9). Although the data are incomplete and no real trends are apparent, ambient levels at the Atlantic stations generally match Canadian and U.S. levels[3,4].

NITROGEN DIOXIDE

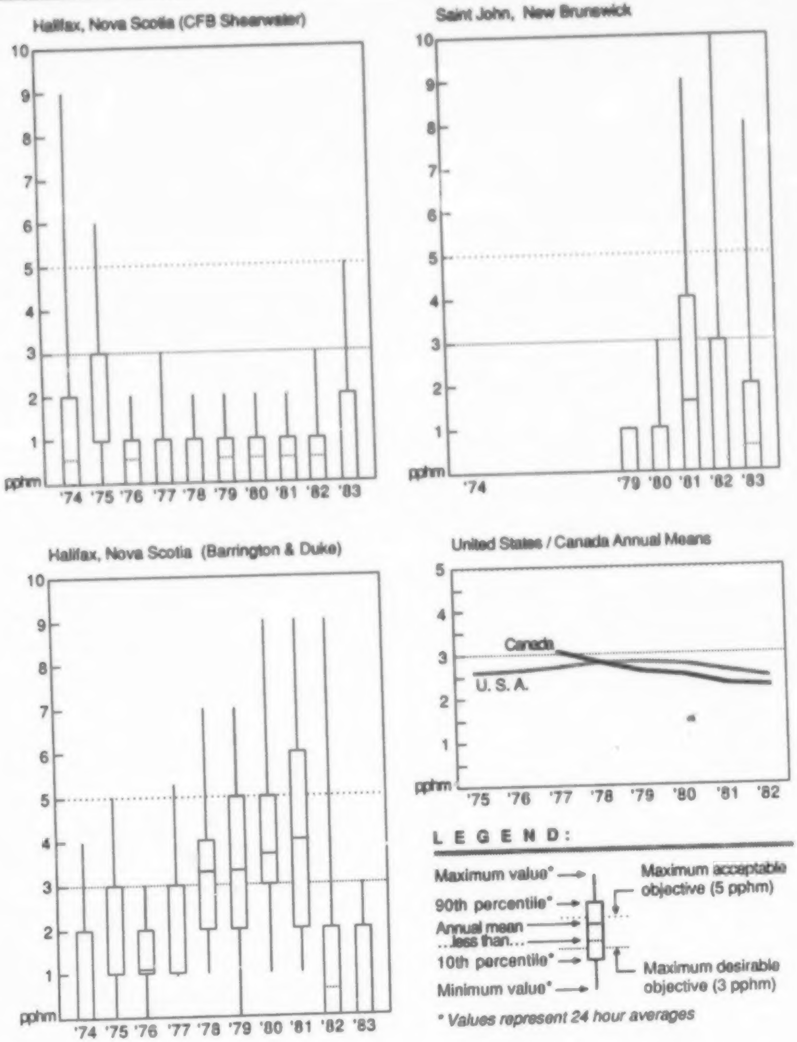


Figure 7 Ambient air monitoring trends for nitrogen dioxide (NO_2) in Atlantic region cities (1974-1983)[2]

TABLE 6
Estimates of Non-Point Source Emissions of Carbon Monoxide (CO) in the Atlantic Region (1980) (tonnes/year)

Source	N.S.	N.B.	P.E.I.	Nfld.	Atlantic Region
Gasoline-powered Motor Vehicles	266,393	176,135	34,963	111,991	589,482
Slash Burning	30,279	55,887	1,853	18,625	106,644
Fuelwood Combustion	25,612	20,632	6,959	31,275	84,478
Non-Highway Use of Gasoline	5,299	26,491	6,569	3,246	41,605
Off-Highway Mobile Sources	5,764	11,728	560	6,463	24,515
Solid Waste Incineration	3,587	7,451	303	913	12,254
Diesel-powered Engines	3,614	2,651	478	2,898	9,641
Forest Fires	1,677	4,954	118	1,679	8,428
Residential Fuel Combustion	2,609	422	76	302	3,409
Industrial Fuel Combustion	1,228	525	11	369	2,133
Commercial Fuel Combustion	212	188	515	121	1,036
Structural Fires	420	272	42	129	863
Electric Power Generation	31	9	—	531	571
Cigarette Smoking	68	56	10	45	179
Ferrous Foundries	25	4	2	—	31
TOTALS	346,818	307,405	52,459	178,587	885,269

Source: Environment Canada. EPS, 1982[5].

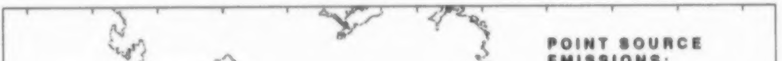

POINT SOURCE EMISSIONS:
CARBON MONOXIDE (1980)
LEGEND:
<100 tonnes/year
100-1000 tonnes/year
1,000-10,000 tonnes/year
10,000-100,000 tonnes/year
0
100
200
Km

Figure 8 Point source emissions of carbon monoxide (CO) in the Atlantic region (1980)[5]

CARBON MONOXIDE

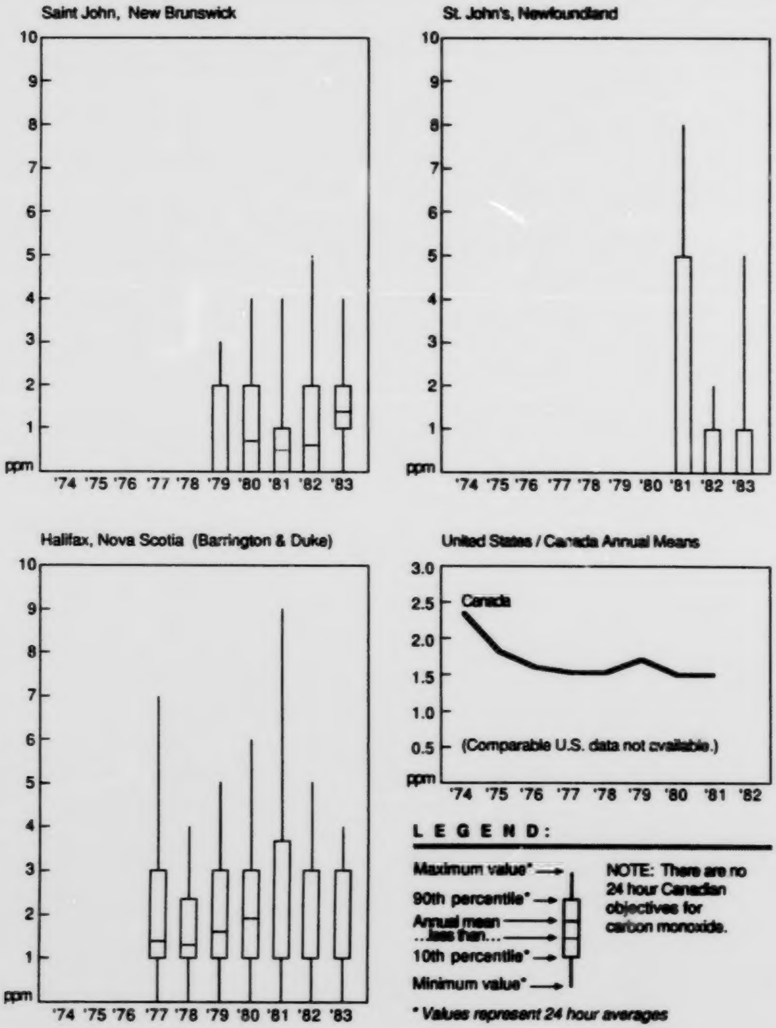


Figure 9 Ambient air monitoring trends for carbon monoxide (CO) in Atlantic region cities (1974-1983)[2]

1.1.5 Ozone (O_3)

Ozone is the principal species of several oxidizing gases known collectively as total oxidants[3]. Ozone is not emitted directly from a source as are other pollutants, but forms as a secondary pollutant. Its precursors are hydrocarbons and nitrogen oxides, which react chemically in sunlight to form ozone. These hydrocarbon precursors are emitted in the Atlantic region principally from gasoline-powered motor vehicles, petroleum refineries, surface coating, solvent use, and wood combustion (Table 7), (Figure 10). Ambient air quality objectives for ozone have been set on the basis of known adverse effects on vegetation, materials and human health[3]. Health effects consist of irritation of the respiratory tract, coughing, chest pains, decreased lung functions, increased vulnerability to infection and an increase in asthma attacks[1].

TABLE 7
Estimtes of Non-Point Source Emissions of Hydrocarbons in the Atlantic Region (1980) (tonnes/year)

Source	N.S.	N.B.	P.E.I.	Nfld.	Atlantic Region
Gasoline-powered Motor Vehicles	24,484	16,465	3,145	11,611	55,705
Diesel & Gasoline Marketing	8,293	7,544	1,237	4,369	21,443
Application of Surface Coating	3,126	2,529	450	1,980	8,085
Solvent Use	2,669	2,194	386	1,788	7,037
Off-Highway Mobile Sources	2,086	1,923	98	2,055	6,162
Crude Oil Production	1,728	2,534	—	164	4,426
Diesel-powered Engines	1,269	961	177	1,050	3,457
Non-Highway Use of Gasoline	282	1,408	349	172	2,211
Slash Burning	572	1,055	35	352	2,014
Fuelwood Combustion	1,177	174	59	264	1,674
Dry Cleaning	578	475	84	387	1,524
Landfill Sites	554	457	80	375	1,466
Forest Fires	252	743	18	252	1,265
Solid Waste Incineration	308	635	2680	1,049	
Residential Fuel Combustion	675	189	35	123	1,022
Industrial Fuel Combustion	266	129	2	113	510
Structural Fires	210	136	21	65	432
Plastic Fabrication	238	190	—	—	428
Bakeries	100	83	4	41	228
Commercial Fuel Combustion	45	36	110	17	208
Electric Power Generation	92	—	164	175	
Tire Wear	27	18	4	11	60
Wood Industry	8	14	—	—	22
TOTALS	48,956	39,894	6,320	25,433	120,603

Source: Environment Canada. EPS, 1982[5].

Ozone measurements have only been reliable and consistent in Canada since 1979. The 1-hour acceptable air quality objective for ozone (0.08 parts per million) has been exceeded at most urban sites in Canada where monitoring has been carried out. The 24-hour average reported for Atlantic Region stations showed the majority of readings above the maximum acceptable objective (Figure 11)[16]. The highest ozone levels generally occur during summer afternoons when high temperatures and strong sunlight promote photochemical reactions. Severe crop damage is occurring both in the U.S. and southern Ontario, where the acceptable O_3 dose is frequently being exceeded. In Ontario, it has been found that if levels of O_3 are maintained at or below 0.03 ppm (7-hour seasonal average), little or no O_3 injury or damage to crops will occur[17]. In the Maritimes, mean growing season concentrations are close to, but below the threshold for crop and forest effects, although the current monitoring data base is limited[16].

Ground level ozone — which is considered a pollutant — should not be confused with the stratospheric ozone layer located about 10 km high in the atmosphere, a layer which shields the earth from ultra-violet rays. Concern over potential reduction of the necessary levels of ozone in the stratosphere by reactions with fluorocarbons from aerosol cans resulted in the banning of their use in Canada in 1980. Considerable

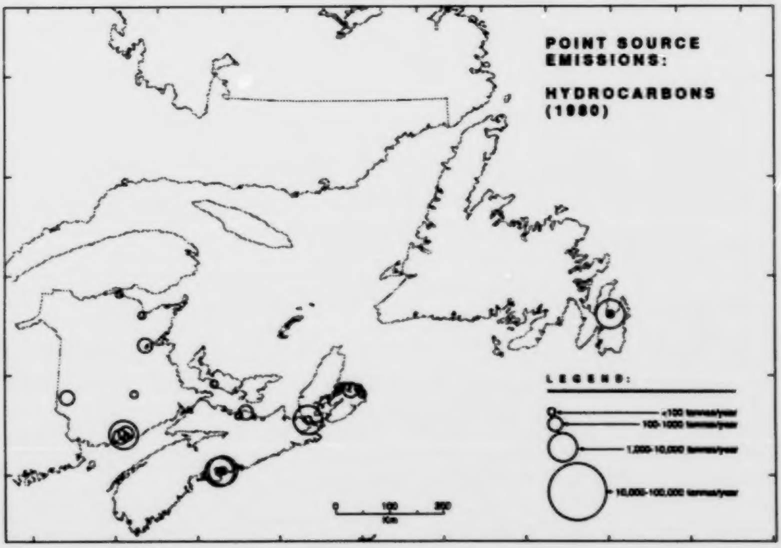


Figure 10 Point source emissions of hydrocarbons (HC) in the Atlantic region (1980)[5]

OZONE

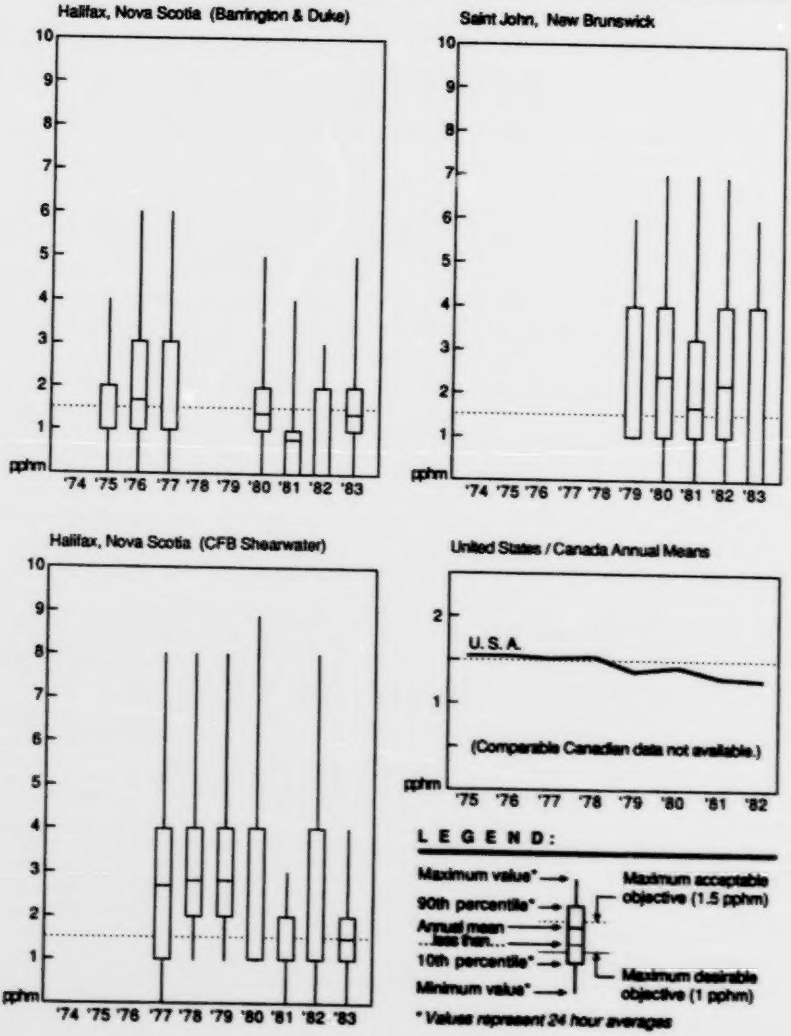


Figure 11 Ambient air monitoring trends for ozone (O_3) in Atlantic region cities (1974-1983)[2]

international attention has recently been directed toward control of human activities that affect the ozone layer.

In most of Eastern Canada, long-range transport of ozone is thought to be the dominant mechanism leading to elevations in ozone levels, with local precursor emissions playing an apparently insignificant role. Although volatile organic compound (VOC) emissions decreased 13% from 1975 to 1982[4], further reductions in Canadian and American NO_x and volatile organic compound (hydrocarbon) emissions appear necessary to reduce impacts in eastern Canada[16].

1.1.6 Lead

The largest single source of atmospheric lead emissions in Canada (greater than 70%) is the automobile. (Industrial point sources of lead are discussed in section 1.2.2). In response to concerns expressed about the health implications of continuing exposure to lead, Environment Canada introduced the Leaded Gasoline Regulations in 1976, which set the maximum permissible level of lead in gasoline at 0.77 grams per litre[18]. (See also the section on Human Health and the Environment). Lead-free gasoline (lead content of 0.0132 grams per litre) was also introduced to reduce vehicle lead emissions[19].

By 1980, the decrease in lead emissions from vehicles in Canada had levelled off at about 7,000 tonnes per year. On the advice of the federal Department of Health and Welfare, Environment Canada amended the leaded gasoline regulations in 1982 to further reduce the lead level in gasoline from the existing standard of 0.77 grams/litre to equal the 1981 U.S. level of 0.29 grams/litre, to be effective January 1, 1987. Although the present Canadian maximum is 0.77 grams/litre, the average concentration of lead in leaded gasoline is about 0.44 grams/litre. The new standard should result in reductions of over 60% from the 1982 levels of 7,000 tonnes/year and represents an overall reduction of close to 80% from the pre-regulation level of 12,000 tonnes/year in 1972[18].

The amount of lead in gasoline as a whole is being significantly reduced. Between 1975 and 1984, there has been a 47% reduction in the amount of lead used in leaded gas and increased consumer use of lead-free gasoline from 5.7% of the market in 1975 to 45% in 1984 (Figure 12), a percentage which is projected to grow to 70% by 1990[19].

Despite these efforts, two problems exist at retail gasoline outlets *viz.*, violations of the Lead-free Gasoline Regulations and nozzle switching. The violation rate of the Lead-free Gasoline Regulations at Atlantic region gasoline outlets has been consistently higher than the national violation rate, but has steadily declined since 1979 and has been lower than the national rate since 1982 (Table 8).

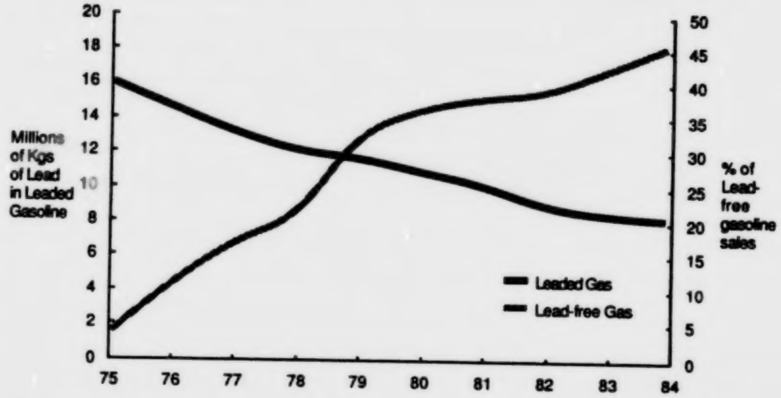


Figure 12 Amount of lead used in leaded gasoline and market percentage of lead-free gasoline sales (1975-1984)[19]

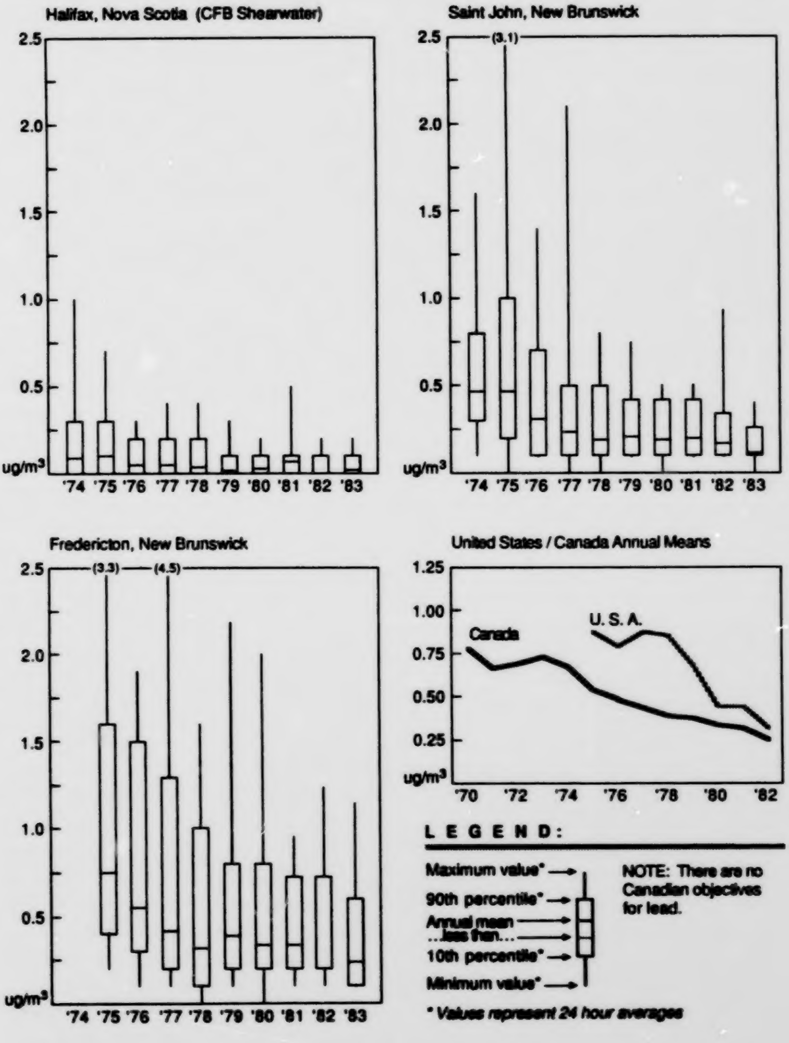
TABLE 8
Violation Rate of the Lead-free Gasoline Regulations at Gasoline Outlets

Year	Canada	Atlantic Region
1978	4.2%	5.9%
1979	4.6%	8.6%
1980	5.9%	6.3%
1981	3.9%	5.8%
1982	5.1%	3.6%
1983	4.4%	2.7%
1984	3.0%	2.2%

Source: Environment Canada, 1985[20].

Nozzle switching, which is the practice of mounting a small diameter (unleaded) nozzle on a gasoline pump dispensing leaded fuel, has been most prevalent in the Atlantic Provinces. The rate of nozzle switching in 1983 ranged between 45% and 59% in New Brunswick, P.E.I. and Newfoundland, but was virtually zero in Nova Scotia, due to legislation enacted in 1980 that specifies nozzle size. P.E.I. passed similar regulations in 1984. Nozzle switching allows a vehicle equipped with a catalytic converter and a narrow gasoline inlet to be misfueled with leaded gas, which renders the catalytic converter inoperative due to lead fouling, resulting in higher emissions of hydrocarbons and carbon monoxide in

PARTICULATE LEAD



NOTE: There are no Canadian objectives for lead.

** Values represent 24 hour averages*

Figure 13 Ambient air monitoring trends for lead (Pb) in Atlantic region cities (1974-1983)[2]

the vehicle exhaust. A catalytic converter in proper operating condition can reduce these emissions by 80-90%[19].

Lead in ambient air is present as a component of suspended particulates. Particulate lead is monitored at 11 NAPS stations in the Atlantic Region: 4 in Halifax/Dartmouth, N.S., 2 in Sydney, N.S., and 1 in each of St. John's, Nfld., Charlottetown, P.E.I., Glace Bay, N.S., Fredericton, N.B., and Saint John, N.B. (Figure 13). No ambient air quality objectives have been established for lead in Canada. Nevertheless, data for the period 1974 to 1983 show a definite decline in the annual means at all stations in the region. These parallel the national declines in both Canada and the U.S.[3,4].

1.2 Point Source Emissions of Hazardous Air Pollutants

In addition to the NAQOs for conventional pollutants which have adverse environmental and health effects at high concentrations, there are regulations specifically limiting the emissions of five especially toxic substances. These pollutants (mercury, lead, arsenic, asbestos and vinyl chloride) are known to constitute a threat to human health at levels produced by uncontrolled sources. Regulations under the Clean Air Act have been passed to control the emissions from mercury-cell chlor-alkali plants, secondary lead smelters, asbestos mining and milling plants, vinyl chloride or polyvinyl chloride plants, and metallurgical industries.

In the Atlantic Provinces, there are several point sources to which these regulations apply. There are two mercury-cell chlor-alkali plants (Canadian Industries Ltd., Dalhousie, N.B., and Canso Chemicals Ltd., Abercrombie Point, N.S.), a secondary lead smelter (Surrette Battery Ltd., Springhill, N.S.), and an asbestos mine (Baie Verte Mines Ltd. (formerly Advocate Mines), Baie Verte, Nfld.). There are no known point sources of vinyl chloride or arsenic which are subject to the regulations in Atlantic Canada. Industrial point sources of fluoride in the Atlantic region are subject to provincial regulations, and include the Electric Reduction Company (ERCO) elemental phosphorus plant in Long Harbour, Nfld. and the Belledune Fertilizer plant in northern New Brunswick.

1.2.1 Mercury

Major sources of atmospheric mercury emissions in the Atlantic region (summarized for 1978) include: chlor-alkali plants, paint application, petroleum and coal combustion and fluorescent tube breakage[21].

Canadian atmospheric mercury emissions declined by 90% between 1970 and 1978. This was largely a result of the federal air pollution control regulations in the chlor-alkali industry which required compliance by 1978. By late 1978, negotiated controls were installed and operating at both chlor-alkali plants in the Atlantic region and these have been in compliance with the emission regulations since 1979. Total mercury emissions from the two plants declined by 75% from 1978 (517 kg) to 1984 (124 kg), further reducing public exposure. An ambient air survey in the vicinity of the Dalhousie plant in 1978 showed that local residents were not exposed to excessive levels of mercury[22].

Despite the success with which the regulations governing mercury emissions from chlor-alkali plants have been implemented, other sources such as the combustion of petroleum and coal have increased in significance. As mercury is readily vapourized, the combustion of fossil fuels for power generation leads to the emission of about 90% of the mercury in the fuel. Given the significant increase in the use of coal for power generation in the region since 1978 (74% increase) and the average mercury content of coals in Nova Scotia (0.14-0.30 mg/kg) and New Brunswick (0.60-1.23 mg/kg), coal-fired generating stations now represent the major source of atmospheric mercury emissions in the Atlantic region (Table 9). The control of mercury emissions from combustion sources is not feasible.

TABLE 9
Mercury Emissions from the Combustion of Coal in Nova Scotia and New Brunswick (1982)

Province	Amount of Coal(1) Burned (1982) (tonnes/yr)	Mercury Content(2,3,4) of Coal (mg/kg)	Proportion(2) Vapourized	Amount of Mercury Released to Atmosphere (kg/yr)
N.S.	1,879,000	(0.14-0.30)	0.9	237-508
N.B.	578,000	(0.60-1.23)	0.9	312-640

(1) Statistics Canada, 1978[23].

(2) Batelle. Pacific Northwest Laboratories, 1985[24].

(3) Landheer, *et al.*, 1982[25].

(4) Sherbin, I.G., 1979[26].

1.2.2 Lead

While the majority of atmospheric lead emissions in Canada result from automobiles, (see section 1.1.6), industrial point sources can be signifiant local contributors. Surrette Battery Ltd. in Springhill, N.S., produces lead-acid batteries for automotive, marine and industrial use. The plant has been a source of lead contamination to the surrounding air, vegetation and soil since 1959. Lead concentrations of 4-189 mg/kg and cadmium concentrations of 3-13 mg/kg were found in vegetation around the plant in 1977[27]. Implementation of the Secondary Lead Smelter Emission Regulations since that time has brought the major emission source within the smelter into compliance. Emissions of lead and particulates have decreased by over 95%, thereby resulting in reduced public exposure. The lead scrap furnace stopped operation in December 1981 and blood lead levels of the workers, (a short-term indicator of ambient lead levels), have dropped dramatically since then. Similar success was achieved at the CNR brass foundry in Moncton, N.B. in 1984, by the installation of new furnaces and filter controls. A source test there in June 1984 indicated that total particulate and lead emissions were well within authorized limits.

1.2.3 Asbestos

Baie Verte Mines Ltd. (formerly Advocate Mines Ltd.), located in Baie Verte, Nfld., is an asbestos mining and milling complex. In the early 1970s, local residents had expressed concern over atmospheric asbestos fibre concentrations in the area[28]. (See also the section on Human Health and the Environment). Emission sources of asbestos fibre included the tailings disposal site, ore drying operations, the primary and secondary crushers, and dry rock storage. Ambient air surveys conducted by EPS in 1974 and 1975 in the Baie Verte area indicated that the atmospheric concentrations of asbestos fibres exceeded the air quality objectives proposed for Ontario.

A multi-million dollar air pollution control clean-up program at the mine/mill complex was undertaken, and by late 1979 the major sources of asbestos emissions were under control, as required by the Asbestos Mining and Milling Regulations of the Clean Air Act. Improvements were also made by the company to reduce fugitive dust emissions from tailings handling and storage, drilling operations and vehicle movements within the complex[29].

Ambient air quality surveys carried out in the vicinity of the complex in 1979 and 1980 showed that almost one-quarter of the samples collected in Baie Verte exceeded the 24-hour Ontario Ambient Air Quality Objective for asbestos. These surveys suggested that the asbestos fibres measured could not be consistently attributed to the mine/mill complex. Source testing in 1983 and 1984 showed that all test results complied with the 2 fibre per cubic centimetre requirement of the Regulations. This suggests that the asbestos fibres are emanating from fugitive sources in the area in general, including the possible re-entrainment of deposited asbestos fibres from the surface of the ground. A major program of paving gravel roads in the area should also help to reduce fugitive asbestos fibre dust in the area and decrease public exposure and potential health impacts from asbestos fibres.

1.2.4 Fluoride

There are two sources of atmospheric fluoride emissions in the Atlantic Provinces: the Electric Reduction Company (ERCO) elemental phosphorus plant in Long Harbour, Newfoundland and the Belledune Fertilizer plant in Belledune, N.B. Both plants have been operating since 1968. Shortly after operations began at ERCO, vegetation in the area of the plant began to show signs of fluoride related damage[30]. Fluoride, which is present in the phosphate rock used as a raw material at the plant and which is lost to the atmosphere during the process, causes leaf damage in plants and skeletal deformities in mammals. By 1976, when the company began a program to reduce its emissions, vegetation had been damaged in an area greater than 75 km^2 around the plant. Vegetables and blueberries harvested near the plant contained high fluoride levels within their tissue and on the surface of the leaf or fruit. Rabbits found in the area showed excessive tooth wear and skeletal deformities due to their high fluoride levels. There were, however, no adverse health effects observed on the surrounding human population[28].

By 1979, improvements to the scrubber system at ERCO had reduced fluoride emissions to less than 10% of their pre-1976 levels and greatly reduced the area affected by fluoride emissions. Further emission controls installed in 1980 resulted in another substantial reduction in fluoride emissions. However, from 1982 to 1984, the frequency of occasional elevated fluoride emissions increased such that 1984 emissions were in the range recorded in 1979. Ambient air concentrations also increased from 1982 to 1984, to the point where the provincial 30 day regulation for gaseous fluoride (0.45 $\mu g/m^3$) was exceeded during the early summer of 1984. Fluoride levels in vegetation have also exceeded the provincial regulations at sites within 5 km of the plant. Fluoride concentrations in berries and drinking water in Long Harbour are nevertheless within acceptable standards. Additional control measures are currently being designed to combat this increase in fluoride emissions[31].

At the Belledune Fertilizer plant in northern New Brunswick, the provincial maximum allowable fluoride emission has not been exceeded and emissions have remained fairly constant since 1978. This is largely the result of the plant operating at less than full capacity[32]. Ambient air monitoring results in the vicinity of the plant show no real trend over time or according to distance from the plant. The same is true in samples of forage and vegetation in the Belledune area, which are mostly below the Newfoundland provincial regulation of 35 ppm.

1.3 Acid Rain

Acidic precipitation, commonly referred to as acid rain, includes rain, snow, freezing rain, hail and fog with a pH below 5.6, (the pH of normal rain). Acid rain is formed in the atmosphere as a result of emissions of sulphur dioxide (SO_2) and oxides of nitrogen (NO_x), from the combustion of fossil fuels. These substances combine with moisture in the atmosphere to form sulphuric and nitric acids. Acids formed in this way can be deposited over 1,000 km downwind from their source[33], as can other contaminants such as metals, PCBs, PAHs and pesticides. Organic contaminants have been recorded in rainfall in Nova Scotia and Prince Edward Island[34], and in plankton directly after rainfall in the Gulf of St. Lawrence[35]. This section will, however, focus on acid rain. The atmospheric transport of other contaminants is discussed in Chapter 2.

1.3.1 Sulphur Dioxide

Up to 80% of the sulphur deposited in Atlantic Canada is emitted as sulphur dioxide (SO_2), principally from non-ferrous smelters and thermal power plants in Central Canada and the United States[11,36] (Table 10, also see section 1.1.2 for regional SO_2 emission sources). The construction of tall stacks in the 1960s improved air quality adjacent to emission sources, but increased sulphur deposition in eastern Canada and the northeastern United States. Total SO_2 emissions have decreased slightly since 1975[36], resulting in a general stabilization of sulphur deposition in the Atlantic region over the past 5 years[11], but it continues at a level where aquatic impacts are apparent.

Total sulphur deposition in the Atlantic Provinces is estimated to be 317,000 tonnes per year[37]. Sulphur deposition in the three Maritime Provinces is above the 20 kg/ha/yr target level where no impacts would result in moderately sensitive areas[11]. Sulphur deposition is generally highest in mainland Nova Scotia and New Brunswick, gradually decreasing over Prince Edward Island, to below the target level over much of Newfoundland and Labrador[38,37]. This deposition is very episodic with pronounced monthly or annual fluctuations due to changing weather conditions[11]. In addition, sulphur deposition can be compounded by nearby emission sources. An estimated 61% of the total sulphur deposition at a rural site 25 km west of Halifax was from emission sources in the Halifax-Dartmouth area[15].

In spite of the potential for increased local emissions and deposition, the long-term forecast for SO_2 emissions is encouraging. The federal and provincial Environment Ministers have agreed to cut SO_2 emissions from eastern Canada to half the 1980 levels by 1994. Canada has also made an international commitment with 9 European countries, pledging to reduce national annual sulphur emissions by at least 30% by 1993. A major problem confronting Canada is the reluctance of the United States to reduce its SO_2 emissions, which is the major source of imported sulphur in the Atlantic region[11].

TABLE 10
Emissions of SO_x and NO_x in The United States and Eastern* Canada ('000,000 tonnes)

	USA				CANADA			
	1975		1980		1975		1980	
	SO_x	NO_x	SO_x	NO_x	SO_x	NO_x	SO_x	NO_x
Utilities	16.7	6.1	15.8	5.6	0.6	0.2	0.7	0.3
Non-ferrous Smelters	2.5	—	1.4	—	2.2	—	2.1	—
Transportation	0.8	9.9	0.8	8.5	0.1	1.2	0.2	1.1
Other Combustion and Industrial Processes	5.7	6.2	6.1	5.2	2.1	0.5	1.8	0.4
TOTAL	25.7	22.2	24.1	19.3	5.0	1.9	4.8	1.8

*East of the Saskatchewan/Manitoba Border.
Source: Canada Sub-Committee on Acid Rain, 1981[33].

1.3.2 Nitrogen Oxides

The atmospheric deposition of nitrogen in eastern North America ranges from 35% to 50% of the rate of sulphate deposition[39]. The major source of NO_x in Canada is the transportation sector, which accounts for approximately 50% of total nitrogen emissions[39] (Table 10). Nitrogen deposition has doubled in Atlantic Canada since 1954[40], and may increase further because emissions, without further control measures, are estimated to increase by 30% by the turn of the century[41].

NO_x can be controlled by reducing emissions from passenger automobiles. The Canadian emission standard is 3.1 grams per mile (although new cars average 1.8 g/mi), while the U.S. standard is a more stringent 1.0 g/mi[33]. Canada will adopt the 1.0 g/mi NO_x standard for 1988 model cars onwards.

1.3.3 Regional Sensitivity

The pH of precipitation samples collected in Atlantic Canada ranges from 3.5 to 6.0, the majority being between 4.2 and 4.8 (a 1.0 pH unit decrease is actually a ten-fold increase in acidity)[12]. In comparison, the average pH of rain and snow collected in Kentville, Nova Scotia between average pH of rain and snow collected in Kentville, Nova Scotia between 1952 and 1954 was 5.7[42]. The pH of rain is lowest in southwestern Nova Scotia and New Brunswick, and is highest in Newfoundland and Labrador[39].

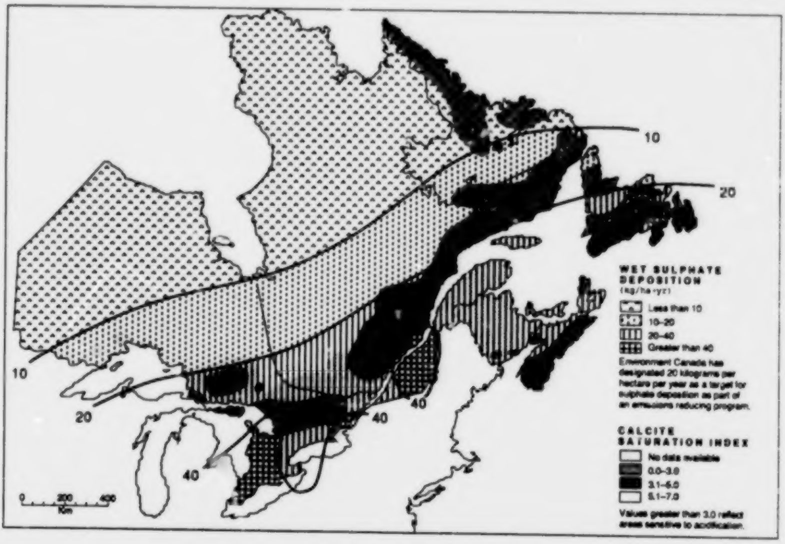

10
20
10
20
40
40
40
40
0 200 400
km
WET SULPHATE DEPOSITION (kg/ha·yr)
Less than 10
10–20
20–40
Greater than 40
Environment Canada has designated 20 kilograms per hectare per year as a target for sulphate deposition as part of an emissions reducing program.
CALCITE SATURATION INDEX
No data available
0.0–3.0
3.1–6.0
6.1–7.0
Values greater than 3.0 reflect areas sensitive to acidification.

Figure 14 Sulphate deposition and sensitivity of waters to acid precipitation in eastern Canada[46]

Many lakes in the Atlantic region are sensitive to acidification because their waters are soft, low in pH and have little or no alkalinity[43]. This low buffering capacity is compounded by large areas characterized by relatively coarse textured glacial till overlying granite or metamorphic bedrock which cannot neutralize acidic precipitation to any great extent[44]. Southwestern Nova Scotia, the Eastern Shore of mainland Nova Scotia and the Cape Breton Highlands are generally highly sensitive to acidification[45] (Figure 14). Southwestern New Brunswick, and much of Newfoundland and Labrador are also regarded as highly sensitive. Northeastern New Brunswick, the west coast of Newfoundland and Prince Edward Island are well buffered, with deep sands or finer soils underlain by alkaline deposits of red sandstones, shales and limestones[44]. Local variations in geology, vegetation, slope and overburden can, however, alter the buffering capacity of a particular watershed[45].

1.3.4 Aquatic Effects

Aquatic environments in parts of the region have been altered due to acidic deposition. The pH of nine river systems in Nova Scotia has declined since 1955, to the point where Atlantic salmon cannot reproduce successfully. Salmon populations in twenty-two other Nova Scotian rivers are seriously threatened[47]. In a study of 42 rivers in Nova Scotia, 13 had a pH less than 4.7, 13 had a pH in the range of 4.7 to 5.0 and only 16 had a pH higher than 5.0[48]. Continuous sampling of the Medway River, in southwestern Nova Scotia, has indicated a statistically significant reduction in pH over the past 30 years (Figure 15)[48].

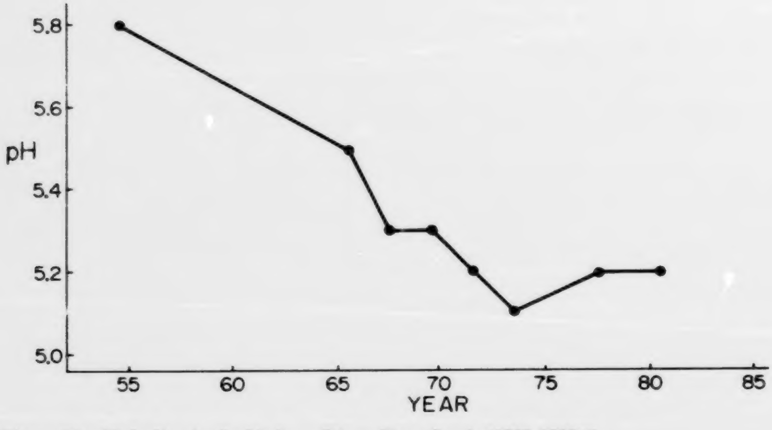


Figure 15 pH decline in the Medway River, Nova Scotia (1955-1980)[48]

An estimated 42% of New Brunswick lakes, 47% of Nova Scotia lakes, 54% of Newfoundland lakes, and 27% of Ontario lakes are highly sensitive to acid rain and are likely being affected by current pH levels[49]. The mean pH of 16 lakes in New Brunswick and Nova Scotia decreased from 6.3 in the 1950s to 5.7 in 1979[50]. Lakes located close to Halifax have deteriorated noticeably, some with a pH dropping below 5.0[40]. There is also emerging evidence that clear water rural lakes in Nova Scotia are being acidified, but the degree of acidification is difficult to determine due to the lack of accurate historial pH data[51]. Small declines in summer pH over historical values were, however, noted for 4 out of 7 lakes sampled in Nova Scotia in 1980-1981[43].

It is difficult to determine the effect of acid rain on aquatic life, especially in relation to other stresses such as over-fishing, physical alteration of habitat and the discharge of other contaminants. Deleterious effects appear to occur in fish at a pH below 6.0; below pH 4.5 most fish populations are wiped out. In an ongoing study at Kejimkujik National Park, only yellow perch and American eel were present in lakes with a pH below 4.6[52]. In a study of salmon angling statistics for 22 Nova Scotian rivers (Figure 16), salmon populations virtually disappeared from rivers with a pH less than 5.1[48].

Increased acidity can alter phytoplankton populations which serve as food for fish or their prey[11]. Low pH acts on fish by altering their salt balance, and by inhibiting spawning, embryonic development and the hatching success. In addition, early life stages tend to be more sensitive to acidification than adults. Fish kills have been reported in Europe and North America[39], particularly when elevated spring runoff from melting snow has caused a ten-fold increase in stream acidity within a 2 to 3 week period[33].

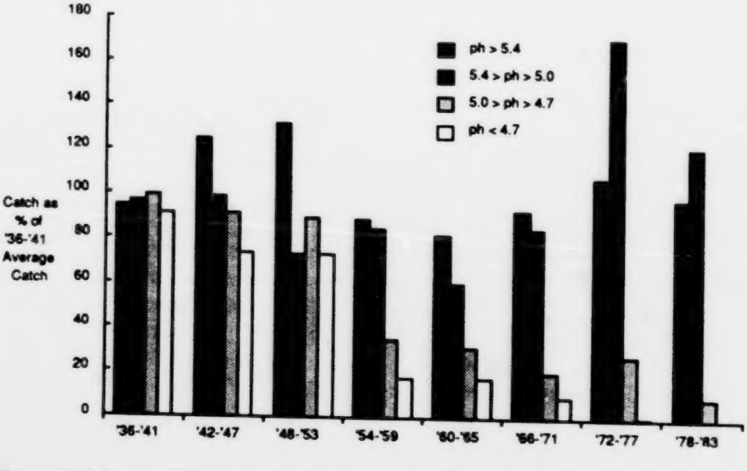


Figure 16 Salmon angling success v.s. pH for 22 Nova Scotian rivers (1936-1983)[48]

Acidic water also mobilizes or dissolves metals from sediments into the water column, thus increasing the concentration of metals that fish are exposed to. This exposure can affect fish in two ways — through the direct toxic action of metals such as aluminum, and through the accumulation of other metals (such as mercury and cadmium) in their tissues. In addition, low pH influences the chemical form of some metals. For example, low pH enhances the process by which the highly toxic methyl mercury is formed from inorganic mercury. Studies have indicated elevated mercury levels in fish from poorly buffered lakes and streams in Quebec, New Brunswick, Minnesota, New York and Maine[53].

1.3.5 Terrestrial Effects

Although reductions in the pH of surface waters have been correlated with reductions in the pH of rainfall, effects on terrestrial ecosystems have not been conclusively demonstrated. The widespread death and dieback of fir and spruce in Germany and Czechoslovakia, and of red spruce at high elevations in the northeastern United States, is thought to be due to acid rain, although other factors such as elevated levels of ozone may also contribute to the damage[53,54].

There is concern that acid rain is increasing the acidity of forest and agricultural soils, resulting in an accelerated loss of nutrients. There is also evidence which suggests that increased soil acidity increases the mobility and biological availability of toxic metals[55]. Evaluating the possible effects of acid rain on forest growth is complicated by the long-term nature of the problem, and by the complex interactions amongst forest composition, soil development, bedrock geology, nutrient availability, and forest management practices[56]. However, conifer forests, which are common in Atlantic Canada, are generally more susceptible than are hardwood stands[56].

1.3.6 Material Damage

Acidic precipitation can accelerate material erosion or weathering, resulting in damaged buildings, roads, paint, automobiles and sculptures with prolonged exposure. The cost of these damages is estimated to exceed $285 million annually in Canada and $5 billion annually in North America[57]. Acid rain, along with salt and local air pollutants, contributes to material damage in the Atlantic region, but there is no documented evidence on the degree of damage.

1.3.7 The Magnitude of the Issue

Acid rain is considered by many Atlantic Canadians to be the major environmental issue in the region. It is, however, difficult to control for a number of reasons, including the large number of emission sources which contribute to its formation. Once it is formed, it is impossible to contain, and both regional and national political authorities must be convinced of the magnitude of the problem before working towards finding an acceptable solution. Acid rain is a unique environmental problem because both industrialized areas and wilderness areas are at risk. Few other types of pollution are capable of rendering a remote, apparently pristine, body of water devoid of fish.

What general remedial action can then be taken to combat the problem? Liming, or the artificial buffering of lakes, has successfully increased the pH of acidified bodies of water, including the water supply for a salmon hatchery in Nova Scotia. However, liming is expensive, often temporary, nearly impossible in remote areas, and treats only the symptom rather than the cause. Joint Canadian and American controls to reduce emissions of SO_2 and NO_x at their source is the preferable solution to the acid rain problem[33].

Chapter 2
Water Quality

Summary

The abundant inland water resources of Atlantic Canada support fish and wildlife, and supply water for drinking, agriculture, industry, power generation and aesthetic enjoyment. Most of the public water supplies in the area are considered to be of acceptable quality in terms of public health and aesthetics, but some other water uses are suffering from varying degrees of degradation.

Many of the popular sport fish populations in the region have been declining over the past several decades, due to decreased water quality and habitat disruption. Heavy inputs of sediment, and excessive nutrients and bacteria, compounded by the insidious effects of acid rain and certain toxic chemicals, have resulted in reduced oxygen levels in certain water bodies, producing reductions in productivity and occasional fish kills.

Improvements have been made to some rivers having severe oxygen depletion, such as the Saint John and St. Croix rivers in New Brunswick. Such improvements have been achieved through concerted efforts from federal, provincial, and international agencies concerned with pollution control, and through the improved compliance of industries and municipalities with effluent quality regulations. Similarly, some advancements are now being made in controlling erosion and siltation of streams and lakes by reducing surface disruption in forestry and construction activities, by encouraging the use of vegetated buffer strips around the borders of water bodies, and by the use of proper techniques in agriculture.

Groundwater contamination has only recently been recognized as a serious threat in this region, as increasing numbers of cases of contamination from bacteria, salt, nitrates, pesticides and petroleum products are being found. Materials disposed of, or spilled on or in the ground, are showing up increasingly

in the groundwater of Atlantic Canada. It is expected that, in the future, more evidence of contamination will be found.

The coastal marine environment is heavily affected by human activities — it is also one of the most sensitive areas. Although Atlantic coastal waters are generally uncontaminated, the Atlantic region does have some areas where the levels of contaminants are high, where biota are at risk, and where implications to the fishery and human health are uncertain.

Most of the population of Atlantic Canada lives on or near the coast and much of the industry is located there as well. Thus the majority of stresses occur along the shoreline and in estuaries and shallow water, the result of either industrial or municipal pollution, or runoff from the land. Although continuous improvements are being made in the quality of the effluents from many of the major coastal industries, similar progress has not been realized with municipal sewage and non-point source pollution. This is reflected in the growing number of shellfish areas closed to harvesting each year. Past abuses continue to create problems in the form of highly contaminated sediments, which have led to lobster fishing closures in Belledune, N.B. and Sydney, N.S.

The offshore waters of the Northwest Atlantic are relatively uncontaminated when compared with other more obviously polluted areas such as the eastern North Sea, the Baltic, or the Mediterranean. This is not surprising in view of the lower population density and the fewer industrial point sources discharging into the western North Atlantic. The very dynamic nature of the Northwest Atlantic tends to disperse most pollutants introduced into it rapidly and widely. Much of the pollution which is found in the offshore Northwest Atlantic seems to arise from diffuse or non-point sources, such as atmospheric fallout of contaminants transported from the North American continent. In most instances, levels of contaminants in the offshore are not high enough to cause any obvious or acute toxic effects, and levels in fish products are usually well within acceptable ranges for public health. In fact, levels of organochlorine insecticides and certain petroleum hydrocarbons now appear to be declining.

2.0 WATER QUALITY

2.1 Inland Water Quality

Like other people in Canada and throughout the world, Atlantic Canadians are dependent on inland waters — the freshwater in wells, streams, rivers and lakes. As a resource, freshwater is a vital requirement for agriculture, industry, power generation, recreational activity, drinking, and aesthetic enjoyment. It is also the essential medium which supports fish and wildlife. Because freshwater is so bountiful in this region, its value as a resource is often taken for granted. As a result, some of our uses of water interfere with others. Practices such as the disposal of industrial wastes, sewage or waste heat into water can deteriorate its quality and limit its future uses[58].

2.1.1 Surface Water Quality

The lakes and rivers of Atlantic Canada are generally smaller in scale than those in other parts of the country, but the region as a whole shares Canada's water-rich topography. Newfoundland and Labrador have the most surface water — more than 8% of their total land surface. The Churchill River in Labrador is the largest watershed in the region, draining 92,500 km^2 of land, and culminating in a powerful average river flow of 1,650 m^3/s. In comparison to Labrador, the rivers on P.E.I. are tiny, and few are longer than 16 km. This island is also dotted with ponds. Nova Scotia, on the other hand, is a consistent mix of short rivers and more than 9,000 small lakes. New Brunswick is similar to Nova Scotia, except that it has fewer lakes and longer rivers[58].

In order to protect the various uses of surface water, the federal and provincial governments have established water quality objectives. Water quality is measured through regular monitoring programs which determine if the parameters of concern meet or exceed these objectives. In general, where a parameter exceeds its objectives, there is a threat to one or more of the uses of the water. For example, in the case of contact recreation, a high bacteria count may mean that an area should be posted as closed to swimming. In the case of freshwater aquatic life, low dissolved oxygen or high metal levels may mean the death of a proportion of the fish population, or the occurrence of a chronic effect, depending on the specific objective and the amount by which it is exceeded.

Although no overall assessment of the quality of freshwater resources in the Atlantic region is possible at this time, data from some of the more intensively monitored water bodies provide some evidence of the state of the resource. Table 11 outlines the various uses of surface waters in the region and how the quality of water for these uses is judged.

2.1.1.1 Uses of Surface Water

2.1.1.1.1 Domestic Supply

The sources of water supply tend to differ in the four Atlantic Provinces. In Newfoundland, the majority of the systems (90%) rely on surface water for their supply. In P.E.I., it is the opposite extreme, where virtually all water supplies utilize groundwater as a source. In New Brunswick, roughly one-third of the population relies on surface water. In Nova Scotia, although approximately 50% of the population uses ground water, almost 94% of the population that is serviced by public water systems use surface water[59].

The definition of "good quality" water for domestic supply relates to it being potable; that is, water that is safe, palatable and aesthetically pleasing to the consumer. Quality is measured against the Guidelines for Canadian Drinking Water Quality, established by the federal Department of Health and Welfare (1978).

There is an array of surface water quality problems with domestic supplies in the Atlantic Provinces, many of which are public health as well as aesthetic problems. Natural surface waters in this region are generally acidic and corrosive, and colour and turbidity often exceed the objectives of the Drinking Water Guidelines. In many instances iron and manganese and occasionally bacteria exceed the guideline recommendations. Colour, while apparently an aesthetic problem, can in fact be a potential health problem[59]. (See also the section on Human Health and the Environment).

The need for improvements in the quality of water available for drinking is a major concern in Atlantic Canada. This is particularly true of the communities which use surface water. Most of the public water supplies provide a water that meets the "Acceptable"* Limits of the Guidelines, most of the time. Some fail to do so on an unacceptably regular basis. Very few achieve the "Objective"** Limits of these Guidelines[59].

In Atlantic Canada there appears to be a general acceptance by the consumer of occasional, even regular water quality problems. If some people have to "go on the boil" for a few days in the season as a result of bacterial contamination, this appears to be considered fairly normal. In the majority of the utilities in Nova Scotia for example, it is not possible to achieve the objective limits with simple chlorination[59].

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*Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.

**The ultimate quality goal for both health and aesthetic purposes.

TABLE 11
Assessment of Surface Freshwater Quality in the Atlantic Region

Beneficial Uses	Definition of "Good" Quality	Measure of Quality	Status
Domestic Supply	Potability.	Guidelines for Canadian Drinking Water Quality (1978).	Most of the public water supplies meet the "Acceptable"* Limits most of the time. Some fail to do so on an unacceptably regular basis. Very few achieve the "Objective"** Limits.
Industrial and Agricultural Supply	Sufficient quantity in all cases. Sufficient quality for irrigation and livestock watering.	Site specific needs for quantity. Federal/provincial objectives for quality.	Generally adequate supply. Only a few cases of shortages. Insufficient data to assess quality.
Sport and Commercial Fishing	Water of sufficient quality and quantity to ensure adequate fish populations that are safe to eat.	Catch statistics (Effort vs Catch). Species compositions of catches. Concentrations of contaminants in edible tissue.	No quantitative assessment available. Salmon and trout populations appear to have been declining over the last 25 years. Tissue levels rarely exceed acceptable levels.
Recreation	Waters that are safe and attractive for use in swimming, boating or water contact sports. Relate mostly with health hazards but also to aesthetics and nuisance conditions.	Guidelines for Canadian Recreational Water Quality (1983).	No quantitative assessment available.
Aesthetics	Clean or healthy water as perceived by someone sitting on the bank or floating in a boat.	Subjective — Presence of materials that will settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity; or leading to the growth of undesirable aquatic life.	No quantitative assessment available.

*Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable.
**This level is interpreted as the ultimate quality goal for both health and aesthetic purposes.

With regard to the quantity of water available, most of the major systems in all four provinces have sources adequate to meet the needs of the communities they serve. Nevertheless, some localized supply problems do occur. Shallow dug wells throughout Nova Scotia have experienced depleted storage due to low water tables. About 190 families in the Newcastle/Bathurst, N.B. area went dry for about five weeks in 1982. The communities of Liverpool, Springhill, Truro, Trenton and Westville, N.S. experience seasonal shortages. In other localities, including New Glasgow, Stellarton and Sydney, N.S., the supply is adequate, but the infrastructure for delivery is not. In Newfoundland, the city of St. John's had to invoke a state of emergency relative to water shortages and use during the summer of 1984.

Research is currently being conducted at the Technical University of Nova Scotia into the application of rainwater cisterns to overcome seasonal drought conditions, or to provide good quality drinking water.

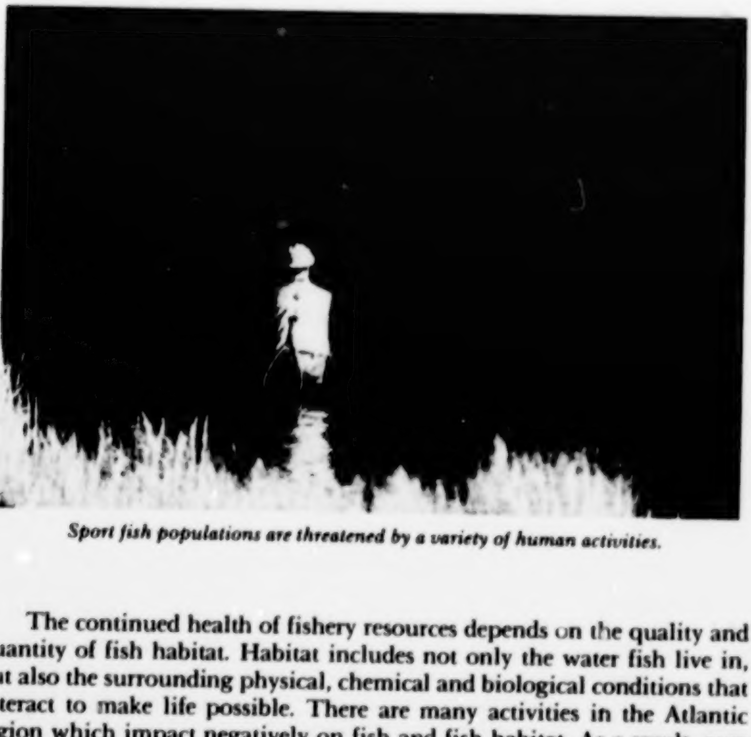
2.1.1.1.2 Industrial and Agricultural Supply

An abundant supply of freshwater is a basic requirement in all of this region's major industrial and agricultural activities. Such requirements include process water in fish and food processing plants, in pulp mills and steel plants, and water for irrigation and livestock watering. The most important criteria is sufficient supply, although the quality of the water is important in some instances (*viz.*, fish and food processing, irrigation, and drinking water for livestock).

Most of these water supply demands are met by systems separate from domestic water supply systems. Most of the pulp and paper and fish plants in all four provinces have their own water supply systems, as do many of the major food processing industries in New Brunswick and P.E.I. Although freshwater is generally abundant in this region and most needs are met, it is not always abundant where it is most desired and some problems do occur with respect to quality.

2.1.1.1.3 Freshwater Fishing

Sport fishing is one of the most popular wilderness recreational activities in Atlantic Canada, and is a strong attraction for many tourists. Two of the region's most important fish, the Atlantic salmon and speckled trout, can be caught in all four provinces[58]. The fishery can be considered to be of good quality when there is a moderate quantity of desirable fish that are safe to eat. Obviously then, should salmon and trout be replaced by less popular sport fish, or their numbers become greatly reduced, it can be said that the quality of the fishery has been degraded. The same is true if the levels of contaminants accumulated in the fish preclude their consumption, or impact negatively on dependent wildlife.



Sport fish populations are threatened by a variety of human activities.

The continued health of fishery resources depends on the quality and quantity of fish habitat. Habitat includes not only the water fish live in, but also the surrounding physical, chemical and biological conditions that interact to make life possible. There are many activities in the Atlantic region which impact negatively on fish and fish habitat. As a result, over the past 25 years or so, many of the "desirable" species of fish which are particularly susceptible to the adverse effects of habitat disruption, have been declining, both in abundance and species composition. Mining effluents, pesticides, pulp mill and food processing plant effluents, municipal discharges, siltation, agricultural runoff, obstructions to fish passage, and acid rain have all affected fish habitat. These disruptions result in physical loss of habitat or restriction of fish movement, and chemical restrictions by toxic metals and organics, lowered pH or dissolved oxygen. Contaminants such as lead, zinc, copper, pesticides and oil are lethal to fish in very small quantities. (See sections 3.1, 3.2 and 1.3.4). The effects of poaching and overfishing on fish stocks, although not quantified, are also considered significant factors in these declines.

The occurrence of arsenic and mercury in fish found in waters close to former gold mining areas in Waverley and Montague, N.S., just outside of Halifax, has been documented. The muscle tissue of many of these fish (white perch and white suckers) contained levels of mercury which made them unsuitable for human consumption (0.5 mg/kg wet wt.). Human health is probably not threatened in this particular situation, because these fish are not popular sport fish and are unlikely to be consumed[60]. (See also the section on Human Health and the Environment).

Salmon and trout require water with at least 5 ppm of dissolved oxygen. In the last 10 years, improvements have been made to severely oxygen depleted rivers, particularly those affected by pulp mills and municipal sewage. As a result, fish have returned to areas of the St. Croix and Saint John Rivers. Nevertheless, there are still many rivers in New Brunswick, as well as the Exploits River in Newfoundland, where more work remains to be done to ensure protection of fish stocks. The regulation of river flow for hydroelectric power generation increases water temperatures during warm weather periods, which continues to kill fish in the Saint John River. With regard to physical obstructions, considerable efforts have been made in the past decades toward the installation of fish ladders around hydroelectric developments[61]. Restocking programs have become more prevalent in New Brunswick and Nova Scotia in recent years, while Newfoundland is stocking previously inaccessible rivers.

Low flow conditions represent a natural threat to inland fish. Such conditions have repeatedly caused closures of the inland sport fishery in many rivers in the western portion of insular Newfoundland. In the summer of 1979, every river in western and central Newfoundland was closed. Serious problems also occurred in 1982 and 1983. Many spawning areas for salmon and trout have recently dried up in Southwest Nova Scotia and the Big Salmon and Hammond Rivers in New Brunswick were closed to salmon fishing in 1981 because the low water levels made the salmon vulnerable to jigging.

2.1.1.1.4 Recreation

Recreational waters refer to those natural waters used primarily for swimming, boating, fishing and other sports involving body contact with water[63]. Quality in this case relates to waters that are safe and attractive for the above uses. The concern here is mainly with health hazards such as fecal contamination or pathogenic microorganisms, but also relates to aesthetics and other nuisance conditions. The measure of quality is the Guidelines for Canadian Recreational Water Quality (1983). There are also more site-specific objectives, such as those which exist for the international portion of the Saint John River (fishable-swimmable objective).

Although poorly quantified, for the most part, recreational waters in the Atlantic region generally meet these objectives. Examples of beach or river closures, or cases of illness, have been cited for portions of the Saint John River and in some of the Dartmouth, Nova Scotia lakes in mid-summer, but these are generally short-lived and infrequent occurences.

2.1.1.1.5 Aesthetics

A less tangible benefit to be derived from surface waters is that gained by simply observing "clean", "healthy" waters. This is obviously a very subjective measure of quality, but provides a real benefit to the individual. Generally, aesthetic quality can be considered to be impaired by: the presence of materials that will settle to form objectionable deposits; floating debris, oil, scum and other matter; substances producing objectionable colour, odour, taste or turbidity, or leading to the growth of undesirable aquatic life[63]. There is no quantitative assessment of the degree of aesthetic impairment of surface waters in the Atlantic region at this time.

2.1.1.2 Sources of Surface Water Quality Degradation

Fundamental to the understanding of water quality is the need to define the problems that affect it; that is — how are the beneficial uses of water being impaired, and what are the causes of their being abused. The problems most important to Atlantic surface freshwater systems are discussed below.

2.1.1.2.1 Siltation

Siltation is a common problem in all four Atlantic Provinces, although the major causes are different in each case[58]. Logging, mining, agriculture, road building and general construction are principal sources of siltation problems.

In Prince Edward Island and parts of New Brunswick, current farming practices are the major contributors to a siltation problem which is increasing every year. Larger field areas with fewer protective hedgerows provide less resistance to wind erosion. It is also common practice to plough in the fall, which exposes the soil to even more erosion by wind and water during winter and spring[58]. Soil erosion rates in New Brunswick have increased by over 5 times since 1945, with farmers in western New Brunswick losing between 22.5 and 45 tonnes of soil per hectare per year. The maximum tolerable level recommended by the N.B. Department of Agriculture is 9 tonnes[64]. In the absence of green belts or other protective measures, as much as 25% to 40% of the soil that runs off a field reaches a water body[65].

Highway upgrading and road construction are important causes of siltation in Newfoundland and Nova Scotia. The main concerns are associated with culverts and bridge crossings. When a highway is built with excessive bank cutting or with steep grades and is not properly drained or protected with silt traps or diversion ditches, a heavy rain can cause washouts and result in extreme siltation of nearby streams or lakes. The construction of Highway 100 to Argentia, Nfld., in 1963-66 caused a washout which silted up the best salmon spawning beds on the Northeast River. The system has never fully recovered. More recently in Nova Scotia, construction standards for stream crossings and siltation control have been developed, and work is continuing on an erosion and sediment control manual which describes proper mitigative measures[66].

Careless logging operations represent a major source of siltation in Newfoundland, New Brunswick and Nova Scotia. Access roads, skidder trails and stream crossings are the major sources of sediment from forestry operations. Road crossings and fords may constitute a continuing source of sediment, as culverts wash out and ditches empty their load of sediment into streams after each fall of rain. Forestry-caused siltation is a significant concern in this region because it is so widespread, and thus has the potential to affect large areas of fish habitat.

In response to these concerns, environmental standards for forest road construction were recently established in Nova Scotia[66] and follow-up field visits are more commonly being made in Nova Scotia and Newfoundland to ensure adherence to desired practices[67].

Siltation resulting from mining and construction is of less importance regionally, although sedimentation rates from individual operations can be extraordinarily high and the localized impacts on water quality may be severe. Erosion rates from construction sites are typically 10 to 20 times that of agricultural lands, and runoff rates can be as high as 100 times greater[65].

Local flooding, erosion and siltation have been common problems associated with land development around large urban centres. A major residential development in Dartmouth, N.S., resulted in heavy loadings of sediment to Cranberry Lake, where the sediment traps were mostly inadequate and poorly maintained. In March 1982, in an effort to overcome these problems, the province of Nova Scotia and the municipality of Halifax released a design criteria manual for the construction of drainage systems to control such runoff. Similarly, in 1984, the city of St. John's, Newfoundland, amended a municipal by-law to restrict development within 15 m and 35 m of streams and ponds respectively. This was done for the purpose of preserving and restoring those portions of the urban streams within its jurisdiction as productive aquatic systems, instead of merely storm water ditches.

Activities on the water's edge contribute to stream siltation.

Salmon and trout are probably the greatest victims of siltation, as they require clean, silt-free gravel in which to spawn. Sediment from erosion blankets the stream bottom, filling in the inter-gravel spaces, thus preventing the flow of oxygen to salmon eggs and young. The result of stream siltation is either rejection of the silted habitat by spawning adult fish, or suffocation and death of eggs and young fish. Silt also smothers and eliminates aquatic invertebrates, such as insect larvae, which are an important food source for salmonids.

Significant efforts have been made recently toward the reversal of damaging trends. The recent widespread adoption of environmental guidelines for the construction of forest access roads and vegetated buffer strips along streams throughout the region may be reducing some of the problems of siltation.

The federal government's Environment 2000 program (1984), initiated 57 projects in the region designed to improve stream/river water quality (20 in each of N.S. and N.B., 9 in P.E.I. and 8 in Nfld.). Efforts were directed toward enhancement and cleanup by focussing on the removal of debris, litter, overgrowth, windfall and deadfall that were obstructing stream flow. There efforts were designed to restore free flowing conditions and enhance natural flushing capacity, with the goal of fish habitat restoration. In P.E.I., some of the projects focussed on establishing or improving streamside greenbelts to improve soil retention and thereby reduce stream siltation. Already some stream beds in P.E.I., which were covered in top soil up to 0.5 to 1.0 metres thick, have been cleared of obstructions and returned to their original clean-gravel substrate[68]. These are certainly positive efforts, but represent work on only a small portion of the affected streams and rivers in this region.

2.1.1.2.2 Nutrients and Bacteria

Agricultural runoff, municipal sewage, industrial outfalls and urban runoff all contribute excess nutrients and bacteria to freshwater systems in the Atlantic region. The two nutrients of most concern are phosphates and nitrates which, in excess quantities, can lead to impairment of recreational capability, affect the potability of water, and in particular lower the dissolved oxygen content necessary for aquatic life. The effects of fecal bacteria and pathogenic microorganisms, on the other hand, relate to human health.

Average annual nutrient losses in the upper Saint John River Basin, for example, are estimated at 0.8 kgs of nitrogen per hectare and 0.15 kgs of phosphorus per hectare[64]. This can lead to enhanced eutrophication, particularly in freshwater lakes and streams with low flows. Although poorly quantified, problems of eutrophication in Atlantic region freshwater systems are by far the exception rather than the rule.

In regard to the disposal of sewage in water systems, Atlantic Canada lags behind much of the country in the development of treatment facilities. While many small communities have sewage treatment systems, many larger centres, including Halifax, Dartmouth, Sydney, Edmundston and St. John's do not.

2.1.1.2.3 Other Surface Water Quality Issues

Acid rain and toxic chemicals are two other factors which significantly affect the quality of surface waters in Atlantic Canada. Each of these is discussed in detail in section 1.3 (Acid Rain) and section 3.1 (Toxic Chemicals).

Some of the most important impacts of acid rain are felt in freshwater aquatic systems. This is particularly true in the Atlantic region, where much of the aquatic resource is situated in areas which are susceptible to acidification. Important among the impacts are a lowering of the pH of some poorly buffered waters, loss of effective reproduction in certain fish populations, mobilization of potentially toxic metals and alteration in plant abundance and composition.

The presence of toxic chemicals in the freshwaters of Atlantic Canada is becoming increasingly apparent. These chemicals, organic and inorganic, originate from both natural and man-made sources, within and outside of the region. The concern over their presence in freshwater stems from the fact that they tend to be widely dispersed, may be highly persistent, may be accumulated in biological tissues, and cause biological change, even in trace concentrations.

2.1.1.3 Improvements in Water Quality

There have been a number of substantial improvements in freshwater quality in the Atlantic region in the last few years. One of the most outstanding success stories is the progress that has been made in the Saint John River Basin[69]. The Saint John River Basin is one of the largest watersheds in eastern North America. For years it has been the recipient of industrial, domestic and non-point source pollution from Maine, Quebec and New Brunswick. The major pollutants affecting its water quality include oxygen-demanding wastes, suspended solids, bacteria and nutrients (primarily nitrogen and phosphorus). The quality of the river, measured in terms of its capability to support swimming, drinking and salmonid life, had been severely degraded.

Through the efforts of international cooperation, the municipal, industrial, commercial and residential wastes that were being discharged into the river basin have been substantially reduced. Between 1972 and 1982 point source pollution was reduced by 88% in terms of biological oxygen demand (BOD) loading, and by 82% in terms of suspended solids discharged. The effect of these changes is illustrated by the marked improvements in dissolved oxygen levels in the upper reaches of the river. This translates into substantial enhancement of the river's water quality.

Despite the progress that has been made in the Saint John River Basin, there is still more work to be done. Non-point sources, which may often be the primary source of water quality degradation in the basin, particularly in terms of lake eutrophication and stream sedimentation, are neither well recognized nor controlled. These sources include logging activities, malfunctioning or inadequate sewage disposal systems at lakefront developments, combined sewer overflows, and leachate from dumps and road salt piles.

Other outstanding problems include the regulation of river flow by hydroelectric developments, which both restrict fish passage and (during periods of high water temperature), periodically result in fish kills. The continued discharge of untreated sewage from Edmundston, N.B., restricts swimming in a portion of the river there, and soil erosion in the U.S. portion of the basin, plus proposed metal mining in Maine, threaten complete restoration.

Overall, the outlook for water quality in the Saint John River Basin is good, particularly because of the improvement in quality of highly stressed waters in the basin — those segments which are receiving effluents from the major industrial and municipal discharges. The International Committee dealing with water quality continues to monitor the river, the municipalities, and the industries in the basin, with the goal of making the waters fit for swimming, drinking and salmonids.

Similar success has been achieved on the St. Croix River which forms the international boundary between southern New Brunswick and Maine. The river has a total length of 124 km, the upper 110 km of which are considered to be in pristine condition. It is only the lower 14 km section between Woodland, Maine and Milltown, N.B., where problems are experienced with water quality, mainly in terms of low dissolved oxygen levels. The problems in the lower reaches of the St. Croix River result from a pulp mill and, to a lesser extent, from municipal discharges and sewer overflows in Woodland and Baileyville, Maine[70]. This pollution input, together with the building of dams and other control structures has had an adverse impact on fish migration[71].

By far the greatest change in water chemistry in the St. Croix River occurred in 1966, when the Georgia-Pacific pulp mill in Woodland, Maine, switched from a sulphate process to the kraft process. During the period 1966 to 1972, the kraft effluent was discharged directly into the St. Croix River with no treatment. From 1972 to 1978, the kraft effluent underwent primary treatment and clarification prior to discharge in the river, but summertime oxygen concentrations were still unacceptably low during this period. Since 1978, the effluent has undergone secondary treatment prior to discharge, which has resulted in considerable improvement in the summertime oxygen regime (i.e. it is now generally near to or above that specified in the water quality objectives). The introduction or upgrading of sewage treatment facilities in several communities along the river has also helped. The improved oxygen regime is now such that the river is capable of supporting an anadromous run of Atlantic salmon[72]. The building and repair of fishways in the last few years has reopened access to fish habitat in the upper reaches of the river.

Although the overall water quality conditions allow fish passage, the river still experiences occasional episodes of high effluent loading during periods of low river discharge. These events result in significant increases in total dissolved salts and BOD loads, followed by subsequent drastic reductions in dissolved oxygen saturation[73]. Attention is now being directed toward coliform pollution, which restricts commercial shellfishing activities in the river, and the potential aesthetic and recreational problems associated with colour and foam from the Georgia-Pacific mill.

2.1.2 Groundwater Quality

Groundwater is one of this region's most important natural resources. It is defined as subsurface water which occurs beneath a water table in soils or rocks or in geologic formations that are fully saturated. The vulnerability of this limited natural resource and the impacts of having taken it for granted are only now starting to be appreciated. Because groundwater lacks visibility, it is difficult to understand and easy to forget. This lack of understanding has, in many cases, led to abuse and abuse has resulted in contamination[74].

In the Atlantic region, the primary use of groundwater is for domestic needs. The definition of groundwater quality therefore relates mostly to "potability", or its suitability for drinking.

Depending on the topography and geology of an area, groundwater may be a more important resource than surface water. Groundwater accounts for 95% of the world's utilizable freshwater resources[58]. In Canada, about 31% of the population depends on groundwater for domestic purposes[61]. In the Atlantic Provinces, groundwater is used for household water supply by more than 50% of the population, or slightly over 1 million people[59]. The dependence on groundwater in the Atlantic region ranges from 100% in the province of P.E.I., to a minimum of 10% in Newfoundland. In New Brunswick, 70% of the province's population depend on groundwater as a source of domestic supply. Industrial water supply, on the other hand, comes mainly from the province's major rivers and lakes. Approximately 50% of the population of Nova Scotia is dependent on groundwater supplies[58].

Traditionally, an individual relying on groundwater was best able to judge the "quality" of the water supply based on aesthetic characteristics. However, newly identified threats to the groundwater resources of Atlantic Canada are only now becoming apparent with the aid of sophisticated analytical techniques. These techniques focus on the potentially more severe impacts of industrial and commercial pollutants.

Groundwater is often thought of as a pristine resource. It has also been generally assumed that once underground, stored water is less vulnerable than surface water to contamination[74]. In contrast with surface water pollution however, subsurface pollution is difficult to detect, is even more difficult to control, and may persist for decades because dilution and natural cleansing are usually very slow[75].

In the Atlantic Provinces, there are apparently more problems with groundwater quality than with quantity[59]. Like surface waters in the region, most of the public groundwater supplies provide a water that meets the "acceptable limits" of the Drinking Water Guidelines most of the time. However, some fail to do so on an unacceptably regular basis. As well, very few achieve the "objective" limits of these guidelines. Nevertheless, the poor quality tends to be associated with aesthetic rather than health problems, although there are exceptions[59].

Most groundwater pollution stems from the storage or disposal of wastes on or in the ground[75]. Rainwater acts to transport dissolved substances downward into aquifers and hence into wells. Because groundwater is so widely used for drinking in the Atlantic region, governments are becoming increasingly aware of the human health risks of waste storage and disposal practices.

Groundwater contamination can be classed into three categories: traditional, natural, and synthetic chemical contaminants. Each may represent a threat to both the public health and/or public acceptability of groundwater.

The present information base on groundwater contamination in the Atlantic region is very limited, thus the following discussion is necessarily restricted to the identification of known or suspected sources of contamination and quantification of inputs where possible. The actual extent of contamination of regional supplies and the resultant effects are poorly known at this time.

2.1.2.1 Traditional Contaminants

Traditional contaminants of groundwater include: bacteria and viruses from malfunctioning septic tanks and leaky sewer pipes; salt from road de-icing; nitrates from agricultural fertilizers; bacteria and nitrates from animal wastes in feed lots, and acid and metals from mining activities[75].

Sanitary sewers in urban areas are intended to be watertight, but in reality, leakage of sewage into the ground is a common occurrence, especially from old installations. In the Atlantic region, 55% of the population is serviced by piped sewage systems[76]. Many of the systems in smaller communities have been built within the last 30 years, whereas the larger towns have systems dating back to the early years of this century. The major cities in each province have part of their systems dating back to the mid-19th century[59]. Sewer leakage can introduce high concentrations of nitrate, organic chemicals and possibly bacteria and viruses into groundwater[75]. For the remaining population, septic tank discharges often contaminate private wells. The problem is magnified by the fact that in many cases, especially in rural communities, the prevalence of septic tanks is paralleled by reliance on private wells for drinking water[74].

Salt is probably the most widespread contaminant of Atlantic region wells. This results primarily from the application of de-icing salts to streets and highways. Salt application, which is a major practice throughout this region in winter, occurs at rates of about 10-18 tonnes/km in most areas, and up to 25-35 tonnes/km in some major urban centres. In Nova

Scotia, approximately 175,000 tonnes of salt are applied to over 12,000 km of roads each winter[77].

Agricultural sources of groundwater contamination include animal wastes and fertilizers. Where animals are confined within a limited area, large amounts of wastes are deposited on the ground. In the Atlantic region, there are approximately 18,000 intensive livestock farms containing over 8.7 million cattle, pigs, sheep and poultry[78]. These contribute salts, organic loads and bacteria into the soil. Nitrate-nitrogen is the most important persistent pollutant that may reach the water table[75].

When fertilizers are applied to agricultural lands, a portion leaches through the soil and into the groundwater supply. This problem is particularly acute in P.E.I., where fertilizers are used extensively in agriculture and all domestic water is supplied from groundwater. Increased nitrate levels in individual wells has been documented[59]. Similarly, 17% of private wells sampled in Carleton-Victoria counties in New Brunswick had nitrite-nitrate levels above the recommended limit of 10 mg/L, with the the most likely source of the elevated levels considered to be agricultural fertilizers.

Both coal and base metal mining take place in the Atlantic region. Whether open pit or underground, these mines invariably extend below the water table, so that dewatering is necessary. The water removed is highly mineralized, with normal characteristics including low pH and high iron, aluminum and sulphate (from the coal mines) and heavy metals (from the base metal mines)[79].

Groundwater may become contaminated when either this highly mineralized water is pumped to the surface (where it is temporarily retained in ponds), or from the leaching of storage piles or old mine tailings and settling ponds at abandoned sites. Acid leachate from coal storage piles at the Victoria Junction coal preparation plant in Cape Breton has been identified in the groundwater, although most parameters are within maximum Health and Welfare recommended limits[80].

2.1.2.2 Natural Contaminants

Not all groundwater contamination results directly from human activities. Contamination from natural sources has been identified in private wells in Nova Scotia and New Brunswick. In Waverley and Harrietsfield, N.S., the Nova Scotia Department of Municipal Affairs has provided bottled water for private water supplies contaminated by naturally occurring arsenic and uranium respectively. Arsenic contamination was recognized as a major problem in parts of Nova Scotia during the 1970s, particularly in Halifax and Guysborough counties, where naturally high concentrations of arsenic are found in the underlying bedrock. Mining of gold veins with associated arsenic left scattered rock and tailings dumps with high concentrations of arsenic. Water percolating through these dumps has led to contamination of well water[81]. The concentration of total soluble inorganic arsenic measured in well water samples in several communities in Halifax County exceeded the Canadian maximum acceptable drinking water guideline of 50 ng As/ml. (See also the section on Human Health and the Environment).

Naturally occurring iron and manganese are the most significant aesthetic problems associated with groundwater in New Brunswick and parts of Nova Scotia[59]. Both of these stain laundry and plumbing fixtures and cause undesirable tastes in beverages. Their presence may promote the accumulation of microbial growths in the distribution system, leading to a slimy coat in piping. The reddish-brown colour which they and organic matter impart to the water is objectionable to consumers[62].

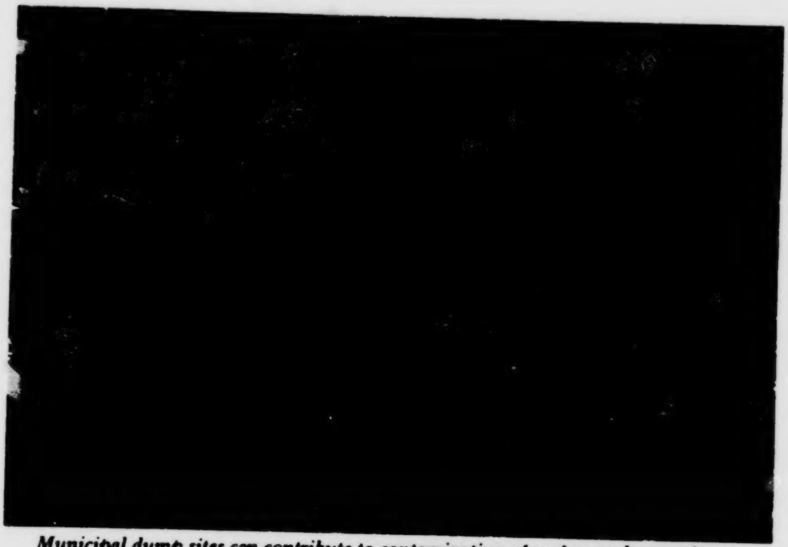
Salt water intrusion is a prevalent groundwater quality problem in Atlantic coastal regions[58]. This can occur in wells constructed close to the ocean, particularly where these wells are over-drawn. Examples of this are apparent in Shippegan, N.B., Elliot River, Summerside, and Brackley Beach Park, P.E.I. and in a development along St. Margaret's Bay, N.S.

2.1.2.3 Synthetic Chemical Contaminants

A more recently recognized threat to groundwater resources is contamination by toxic organic chemicals. Although filtration and adsorption cleanse many pollutants from percolating water, soil and rock strata do not eliminate most toxic chemicals[74]. While a small amount of bacteria, for instance, may be filtered out by a few metres of sand, larger or continuous inputs of harmful substances like those from a landfill may contaminate large portions of an aquifer. Sources of this type of contamination include: land storage or disposal of liquid and solid wastes; leaks and spills of hazardous materials, including petroleum products, and pesticide applications[75].

Groundwater contamination can occur where industrial or municipal wastewaters are discharged into pits, ponds or lagoons, thereby enabling the wastes to migrate down to the water table. In the same way disposal of solid wastes in landfills can create an important source of groundwater pollution. Most landfills are simply refuse dumps, and only a fraction in this region can be regarded as sanitary landfills. (See section 3.3). Nevertheless, at the regional sanitary landfill in Mount Uniacke, N.S., monitoring efforts showed no discernable leachate contamination of the groundwater. This demonstrates that carefully located and properly operated sanitary landfills can prevent groundwater contamination[82].

A recent survey identified over 1,500 abandoned and active dump sites in the Atlantic region, many containing hazardous wastes[83,84]. Many of the sites contain potentially hazardous liquid wastes, very few of which have any lining, possibly allowing contaminants to enter the ground beneath. There are provisions for groundwater monitoring at only a few of these locations. In the late 1970s, a municipal well in Summerside, P.E.I., showed signs of pollution from an adjacent landfill, requiring the drilling of additional wells to replace it[59]. This, and other case studies hint at the geographical extent and severity of the overall problem, but at this point, more information is lacking.



Municipal dump sites can contribute to contamination of surface and groundwater.

Petroleum and petroleum products are another major source of groundwater contamination. Leakage is particularly common from gasoline stations and home fuel oil tanks, especially when they become old and corrode[85]. The great majority of tanks in use are made of steel, and only a small number of these are protected against corrosion. As a result, gasoline may be one of the most common causes of groundwater pollution. Although Canadian figures are not available, an estimated 10-30% of the underground tanks in use to store petroleum products in the U.S. may be leaking their contents to the surrounding environment[86]. Corroded tanks leak slowly, so even a dealer who regularly inventories tank supplies might not detect a leak for a long time. For example, more than 1,000 gallons of gasoline were lost from a service station in Hunter River, P.E.I., over a period of one month.

The awareness of problems caused by leaking storage tanks and pipelines is relatively recent. Resultant problems have been identified in wells in Hillsborough and McAdam, N.B. (More than 42% of tested wells in Hillsborough were polluted by petroleum products). Problems have also been reported in Amherst, N.S. and in P.E.I. (The community of Kensington, P.E.I., required a mini water system to replace private wells contaminated by gasoline). The province of New Brunswick had 71 reported incidents in 1983, which led to the contamination of 91 wells. This represents a ten-fold increase in the past decade. Sources of the contamination included furnace oil, pipelines and underground tanks (including those at abandoned gas stations)[87].

In an effort to address these problems, several of the major oil companies operating in Canada have recently indicated that all of their new underground tanks will either be of fibreglass construction or provided with cathodic protection, in order to prevent underground tank leaks[87]. In 1984, a federal/ provincial/industry task force was formed in the region to develop practical guidelines for preventing, controlling, reducing or eliminating the effects of leaks from underground storage tanks and domestic fuel oil tanks (Atlantic Governments/Atlantic Petroleum Association Task Force on Prevention and Control of Underground Storage Tank Leaks).

In addition to problems from underground storage tanks, petroleum products which are spilled or drained onto the ground through accidents or carelessness can migrate downward to degrade groundwater quality. Other contaminants reach the ground and subsequently the groundwater in a similar manner. The degreasing agent TCE has recently been found in wells serving Amherst, New Minas and parts of Truro, N.S. The use of urea for runway de-icing at the Charlottetown airport has also contaminated local wells.

Agricultural pesticides represent a diffuse source of groundwater pollution that can have serious consequences in relation to the potability of water[75]. In P.E.I., the insecticide aldicarb, which is extensively used in the potato industry, has been detected in domestic wells[88]. It is one of the most acutely toxic agricultural chemicals on the market. Its high solubility and low adsorption to soil particles can cause it to leach through the soil into groundwater. During the 1983 growing season in the province, 50,000 to 100,000 kg were used at a rate of 18-23 kg/ha. Studies indicate that aldicarb persists in some wells, suggesting that degradation can take several years. Although contamination is not at levels considered harmful to human health, its presence is indicative of a potential hazard. A study is now being undertaken by EPS to determine if other water soluble, systemic insecticides are contaminating ground and surface waters in P.E.I.[88]. (See also section 3.2.3).

Wells in New Brunswick have also been contaminated by pesticides, including low levels of fenitrothion in 2 wells and aldicarb contamination of more than half the wells tested in Woodstock in the Saint John River Valley. (See also section 3.2.3). A spill of 2,700 litres of the herbicide Sinox in the Kensington, P.E.I., industrial park forced the temporary closure of 40 private water supplies.

Although many potential sources of groundwater contamination have been identified in the Atlantic region, the limited data base does not permit an accurate estimate of the magnitude of the problem or the most important sources. Data available do however identify the likely sources to investigate. Many of the problems of groundwater contamination have been around for a long time, but it is only recently that they have been receiving attention, albeit less than they deserve. Because of this, groundwater contamination will likely worsen before problems are alleviated. Improvements will only result from a greater understanding of the mechanisms of groundwater contamination and more detailed identification and confirmation of its sources. Only with increased understanding can sources of contamination be controlled to eventually reverse the trends that are becoming apparent. The next five years should see a considerable increase in attention and resources applied to this problem, particularly in those provinces where groundwater is such a vital resource.

2.2 Coastal Water Quality

The Canadian Atlantic coast extends over 40,000 km from the Canada/U.S. border in the Gulf of Maine (the border being set by the World Court on October 12, 1984) to the northern tip of Labrador (Figure 17). Many definitions exist for the geographical boundaries of the "coastal zone," with the ambiguity existing over its landward and seaward extents. For the purposes of this report, coastal waters will be defined as extending from the landward extent of the tide to a seaward extent where human land-based activities have a measurable influence on the chemistry of the water or the ecology of marine life. Functionally, this translates into a few kilometres out from the coast. Coastal waters therefore include estuaries, bays, harbours, saltmarshes and shellfish beds, but exclude the offshore waters and resources of the continental shelf.

Regardless of the limited extent of this "zone," it represents the most sensitive and productive area of the marine environment. It is also the area most heavily occupied and used by human beings. Most of the population of the Atlantic Provinces lives on or near the coast and most of our industry is concentrated there. Consequently, coastal waters receive the greatest input of contaminants from both point and non-point sources, are subject to physical disruption and degradation and experience the cumulative impacts of many activities.

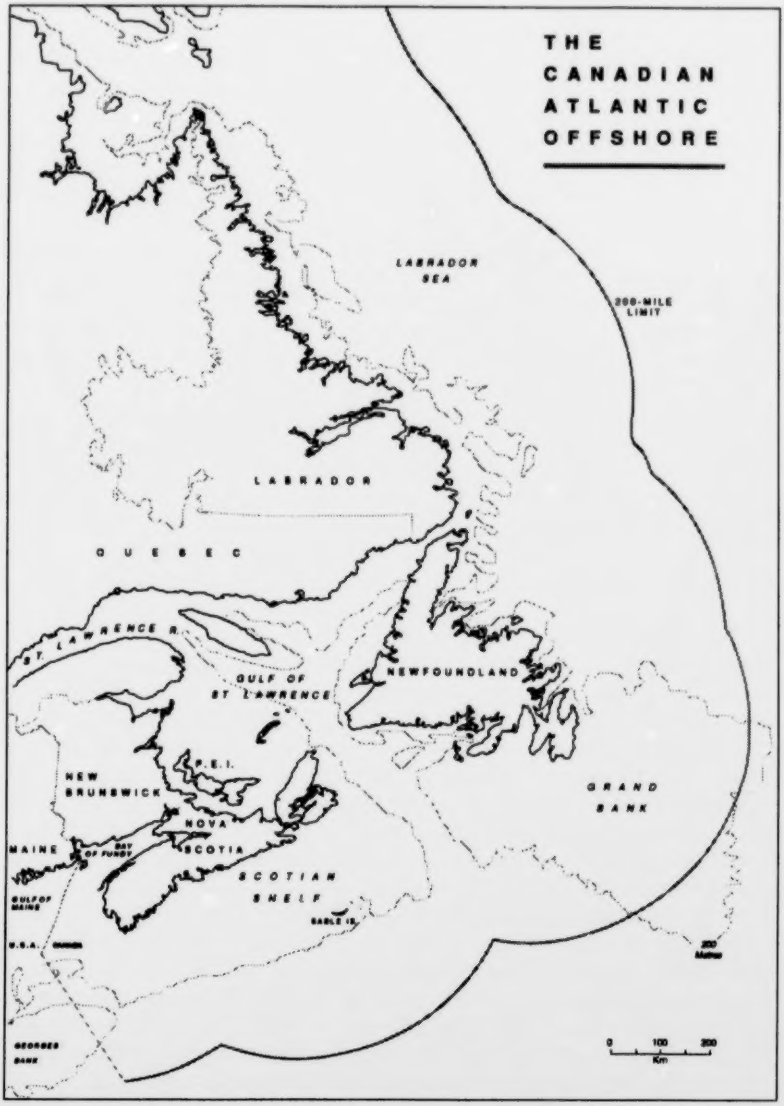

THE CANADIAN ATLANTIC OFFSHORE
LABRADOR SEA
200-MILE LIMIT
LABRADOR
QUEBEC
ST. LAWRENCE R.
GULF OF ST LAWRENCE
NEWFOUNDLAND
P.E.I.
NEW BRUNSWICK
NOVA SCOTIA
MAINE
BAY OF FUNDY
GULF OF MAINE
SCOTIAN SHELF
SABLE IS.
GRAND BANK
U.S.A.
CANADA
200 Metres
GEORGES BANK
0
100
200
Km

Figure 17 The Canadian Atlantic offshore

The principal use of Atlantic coastal waters is for the commercial and recreational harvesting of shellfish, finfish and marine plants, which requires a healthy marine environment in order to flourish. Tourism on the coast also plays a critical role in the region's economy. (Nova Scotia's license plates sport the logo "Canada's Ocean Playground"). Thus an ability to support abundant recreational activities (beaches, boating, swimming, fishing, clam digging) and supply "aesthetic quality" are essential. Canadian Atlantic coastal waters are equally important for marine transportation, industrial water supply, and waste disposal. At the same time they function as critical marine nurseries, as nutrient and food supplies, and as important habitat for both resident and transient fish and wildlife.

The following section outlines the activities and contaminants that affect coastal waters in the Atlantic region, their impacts on coastal resources, their trends in recent years, and the efforts taken to achieve improvement in coastal water quality.

2.2.1 Point Sources

2.2.1.1 Pulp and Paper Industry

The pulp and paper industry is an important resource sector in the Atlantic Provinces, with 20 plants operating in 1984 (Figure 18). These mills produce newsprint (7), bleached kraft pulp (4), groundwood pulp (3), corrugating medium (2), bleached sulphite (3), moulded products (1), tissue (1) and hardboard (1). Many of these plants date back to the early years of the century, thus representing one of the oldest industrial point sources discharging to the marine environment. Depressed business conditions in recent years have resulted in some shutdown time for many mills, particularly those producing newsprint.

Most of the plants in this region discharge potentially toxic oxygen demanding wastes (BOD) and suspended solids to coastal waters. As a result, there have been heavy build-ups of decaying wood fibre in the vicinity of these plants, which has led to physical smothering of the benthos, changes in benthic habitat and oxygen depletion of bottom waters. Research is ongoing to determine the impact of pulp and paper effluent on salmon migrations, where plants discharge to the mouths of rivers. Fishermen at some locations commonly complain of fouling of their nets, foul smells from anoxic sediments and ice-rafting of wood chips and fibre. Up until the early 1960s, mercury was used as a fungicide in pulp and paper mills, which resulted in the contamination of marine sediments. This persists at lower levels in the vicinity of the plants today.

For the pulp and paper industry as a whole, in the Atlantic region, the discharges of BOD and suspended solids (SS) have been steadily declining (Figure 19). Approximately 60% reductions in BOD and 51%

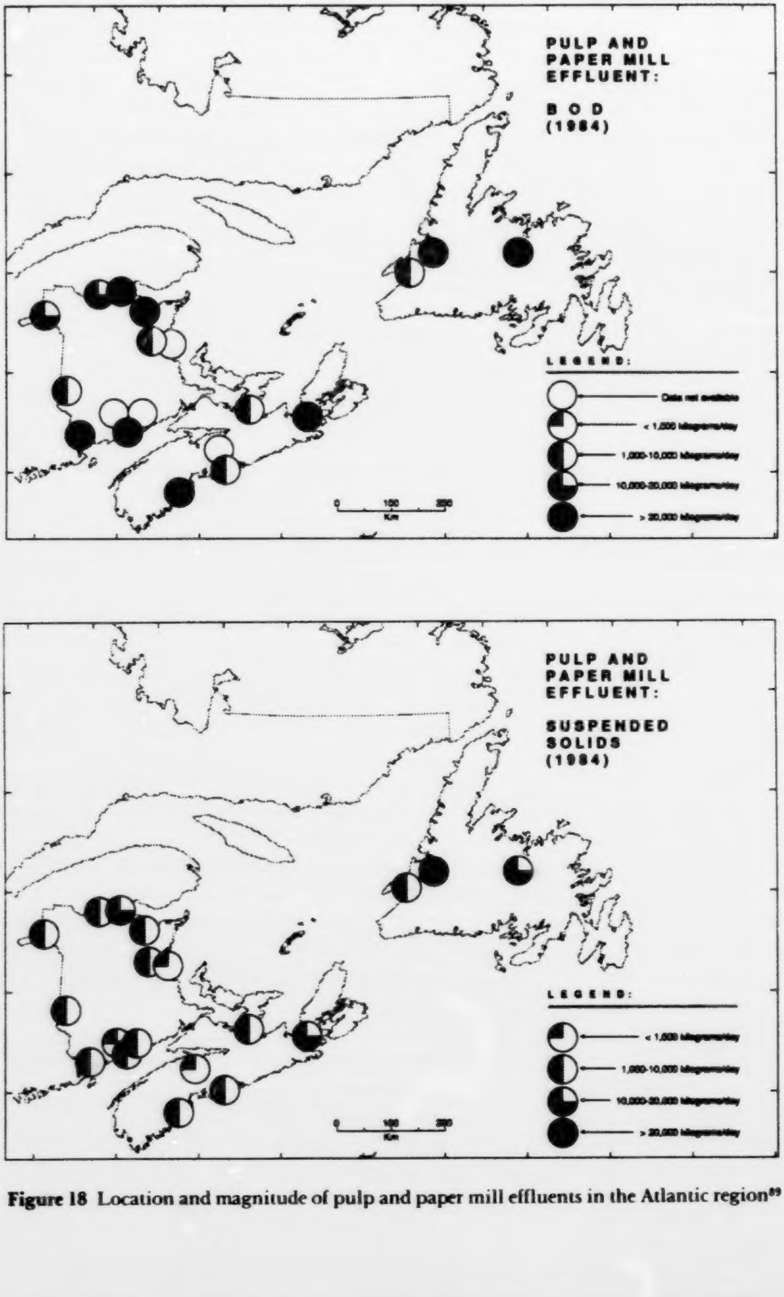

PULP AND PAPER MILL EFFLUENT:
B O D (1984)
LEGEND:
Data not available
< 1,000 kilograms/day
1,000-10,000 kilograms/day
10,000-20,000 kilograms/day
> 20,000 kilograms/day
0
100
200
Km
PULP AND PAPER MILL EFFLUENT:
SUSPENDED SOLIDS (1984)
LEGEND:
< 1,000 kilograms/day
1,000-10,000 kilograms/day
10,000-20,000 kilograms/day
> 20,000 kilograms/day
0
100
200
Km

Figure 18 Location and magnitude of pulp and paper mill effluents in the Atlantic region[89]

reductions in SS were realized in the period 1969-1984. Much of the reduction so far has resulted from combinations of process changes, in-plant controls and external treatment.

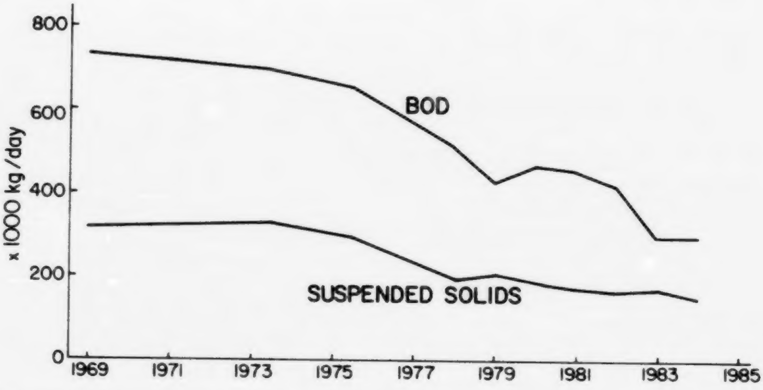


Figure 19 Trends in Atlantic region pulp and paper mill effluent discharges (1969-1984)[89]

More significant perhaps, has been the 5-year federal-provincial modernization program which was initiated at 13 of the 20 mills in the Atlantic region in 1980-81. By 1984, 9 plants were in compliance with the Federal Pulp and Paper Effluent Regulations of the Fisheries Act for suspended solids discharges, with another 3 near compliance. Ten plants were in compliance for BOD discharges, with another four near compliance. All plants should be in or near compliance for BOD discharges if all modernization plans are completed. Eight plants had discharges which met the toxicity requirements and were non-acutely lethal to test fish, but about half of the plants will still have toxic discharges by the end of the program. Nationally, it is expected that by 1986, about 80% of the mills will be in compliance with environmental regulations[90].

2.2.1.2 Petroleum Refining

The petroleum refining industry, long established in the Atlantic region, has resulted in considerable concern over both the quantity and quality of its liquid effluents. Oil refining in this region has suffered economically in the last several years. Two of the five refineries (the Gulf refinery in Port Hawkesbury, N.S. and Ultramar's facility in Holyrood, Nfld.) were completely shut down in 1980 and 1983 respectively, and the other three (belonging to Texaco and Imperial in Dartmouth, N.S. and Irving in Saint John, N.B.) have been operating at reduced capacities[91].

A wide range of organic and metal pollutants are present in refinery wastewaters, oil being the most common contaminant. In an effort to limit these discharges, the federal government, in consultation with the provinces and industry, has developed the National Petroleum Refining Effluent Regulations and Guidelines (1974) under the Fisheries Act. The intent is to limit the discharge of substances which are deleterious to fish. The five regulated parameters are: oil and grease, sulfide, ammonia, total suspended matter (TSM), and phenol.

TABLE 12
Average Loadings of Regulated Parameters from
Atlantic Region Petroleum Refineries (1978-1983) kgs/day

Year	Number of Operating Refineries	Oil and Grease	Sulfide	Ammonia	TSM	Phenol
1978	5	787	2.2	248	1558	344
1979	5	440	1.1	182	775	112
1980	5	221	2.5	149	1497	15
1981	4	396	2.2	219	548	9.0
1982	4	348	1.6	134	535	9.5
1983	4*	259	0.9	157	760	11
% Reduction (78-83)		67%	58%	37%	51%	97%

*4th refinery operated for only first 6 months of 1983.
Source: Environment Canada. EPS, 1985[89].

Since 1980, all refineries in the region have been in compliance more than 98% of the time. On an individual basis, the maximum authorized limits were not exceeded significantly by any refinery in the region. The improved compliance by the refineries is attributable to efforts by the industry to meet the applicable requirements. These have primarily involved the installation or upgrading of treatment facilities.

Table 12 shows the substantial reduction in loadings of the regulated parameters between 1978 and 1983.

2.2.1.3 Fish Processing

There are over 300 fish processing plants along the coasts of the Atlantic region. Effluents from these plants discharge substantial loadings of oxygen demanding organic matter, suspended solids, oil and grease, fecal bacteria and certain organic/inorganic contaminants. Although the effluents from this industry are not routinely monitored, impacts in the vicinity of fish plant outfalls are considered to be very localized and of little anticipated consequence to the overall quality of the receiving environment. Fish meal plants are considered to have a greater environmental impact, because of high BOD and potential toxicity as a consequence of lowered dissolved oxygen. This impact is also local, and individual plants are not viewed as having a broad geographical influence[92]. Quite often, the problem of odours and flies around fish meal plants receives more community response than the problem of effluent discharges.

Most marine fish contain small quantities of polychlorinated biphenyl (PCB). As the oil and wastewater from their cleaning and processing are discharged, the PCBs may accumulate in the sediments in the vicinity of the plants. PCB concentrations greatly in excess of background concentrations (0.005 µg/g) have been measured in samples obtained from several harbours in the Atlantic region which receive effluents from fish processing plants[93].

One of the harbours which has been observed to be most severely contaminated is Petit-de-Grat, N.S., located on the southeast corner of Cape Breton. A number of process streams and effluents from the fish meal plant contained PCB residues up to 0.83 mg/L and sediment concentrations there were as high as 20 µg/g dry weight[94]. Samples which were especially high in PCBs consisted principally of fish offal.

An investigation of several other harbours in the region with operating fish/fish meal plants found PCBs in the majority of the collected samples, but at levels approximately two orders of magnitude lower than those measured at Petit-de-Grat[95]. Significant accumulations of PCBs are likely only to occur where the discharge of high strength effluents and/or the poor dispersal of effluents by the receiving water (such as in the partially enclosed, low energy harbour at Petit-de-Grat) leads to sediments highly enriched in fish waste[93]. There are at least 18 harbours in the region where PCB sediment concentrations are in excess of 1.0 µg/g[96]. Dredging and disposal conflicts arise when it becomes necessary to dredge harbours with PCB sediment concentrations in excess of the Ocean Dumping Control Act limit of 0.1 µg/g.

2.2.1.4 Municipal Sewage

Installation of sewage treatment systems in Atlantic Canada has lagged behind many other parts of the country. "Ribbon development" along the coast is common, and many sewage treatment facilities impact on the marine environment. There are, in addition, many untreated sources ranging in size from single family dwellings to major cities. In the Atlantic Provinces, approximately 55% of the population is served by sewers which collect the wastewaters, but only about 20% of the population is served by central wastewater treatment (Table 13). About 788,000 people therefore discharge municipal wastewater to collection systems that are not connected to wastewater treatment facilities. Assuming an average per capita wastewater generation of 100 gallons per day, approximately 78,800,000 gallons (358,000 m^3) of untreated wastewater are being discharged daily into our environment from communities that have collection systems. In terms of organic loading, assuming an average BOD of 200 mg/L, approximately 80 tonnes of BOD are being discharged daily[97], (about the equivalent of the combined daily BOD loading from three of the biggest newsprint mills in the region). Municipal wastewater discharges are, however, numerous and widely dispersed throughout the region, so that adverse impacts are considerably diluted.

TABLE 13
Urban Population Served by Sewage Treatment Systems*

	% of Urban Population Served	Number of Communities with Sewage Treatment Plants
Nfld.	17%	42
P.E.I.	100%	22
N.S.	28%	76
N.B.	60%	73
Canada	63%	
U.S. (1980)	67%	

*Excludes septic tanks serving non-urban populations of less than 1,000 people.
Source: National Inventory of Municipal Waterworks, 1981[76], (with updating through 1982).

The main effects of sewage discharged into coastal waters are those influencing public health and shellfish harvesting[97]. As well, bathing beaches are widely distributed along the coast of Atlantic Canada, and during the summer months some beaches are subjected to very heavy use. The discharge of sewage into coastal areas can impair water quality at bathing beaches and constitute a potential threat to human health, particularly in the form of intestinal illnesses. Similarly, many of the numerous shellfish growing areas in the region are contaminated by both point and non-point sources. (See section 2.2.2.1).

Although many of the above problems persist in this region, there have been some successes. For example, the discharge of untreated sewage into Charlottetown Harbour in P.E.I. had precluded those waters from being used for traditional purposes for many years. The construction of a new sewage treatment plant in 1975 restored over 1,000 hectares of the harbour for shellfish propagation and the waters are again safe for swimming.

Beaches in Atlantic Canada are heavily used in summer months.

2.2.1.5 Thermal Generating Stations

Thermal generating stations represent the primary source of waste heat released to the marine environment[98]. There are 14 thermal generating stations presently operating in the Atlantic Provinces which generate electricity by burning coal or oil, or by nuclear reaction (Pt. Lepreau station in N.B.). (For a more complete description of thermal generating in the Atlantic region and atmospheric emissions and impacts, see sections 1.2 and 4.2.2).

The localized effects of heated effluents can be significant. A warming of the receiving environment can alter the species composition of the local benthos, or fish if their temperature range is exceeded. Conversely, the warmer waters may attract new species more tolerant of the higher temperatures. A small scale trout rearing project is being conducted on an experimental basis on site at the Nova Scotia Power Corporation (NSPC) Lingan generating station, which takes advantage of the warm effluent for accelerated fish growth[99]. A similar hatchery operates on heat from the Grand Falls generating station in New Brunswick. A larger operation of this nature is possible at the Lepreau nuclear power station.

Thermal pollution in this region has not produced significant adverse impacts. The areas of impact in receiving waters from thermal generating stations are quite limited (1-25 ha), and there is no evidence for the existence of major environmental impacts[98]. Average discharge temperatures range from about 10° to 33°C. A temperature rise of no more than 10°C above ambient in temperate zones is probably adequate to safeguard the area outside a near field zone (within a few hundred metres), provided that physical conditions and outfall design allow for rapid dilution and dispersion[100]. These conditions are adequately met at stations in this region[98].

The Point Lepreau nuclear generating station is the first nuclear reactor operating on the Canadian coastline. (See section 4.2.2.4). Radioactive, thermal and chemical releases are discharged, principally into the marine environment. A monitoring program has been established within DFO to assess the long-term environmental impact of the station on the marine environment. Results to date indicate that there is no discernible impact from the operation of the plant[101]. A second nuclear generating station has been proposed for the same site (Lepreau II), and is presently being reviewed for its potential environmental impact.

2.2.1.6 Steel Industry

The Sydney Steel Company (Sysco), the only steel plant in Atlantic Canada, has been discharging toxic and environmentally hazardous wastes into the South Arm of Sydney Harbour for over 80 years. Aqueous effluents emanating from coking operations, and other plant waste material and by-products, are discharged to a nearby site close to Muggah Creek, commonly referred to as the "Tar Pond"[102]. A complex mixture of hazardous chemicals has accumulated in the Tar Pond, the most prominent of which are polycyclic aromatic hydrocarbons (PAHs). The coke ovens were shut down from December 1983 to December 1985, but in 1981, when the coke ovens were operating at 25% capacity, PAH releases were estimated at 3.5 tonnes/yr. The release of PAHs under full coke plant operation was at least 14 tonnes/yr and likely higher[103]. The major toxicological concern with respect to PAHs is their chronic mutagenic and carcinogenic effects. (See section 3.1.2.3).

The Tar Pond covers approximately 38 ha and is about 1.5 m deep in tar/coal product wastes that contain approximately 1% PAH[104]. The total quantity of PAH compounds in the Muggah Creek estuary is estimated to be 3.5 million kg. The area is tidally influenced and movement of toxic waste materials to the South Arm is occurring. (Net release of PAH from the mouth of Muggah Creek into Sydney Harbour is approximately 100 kg/yr). Although the coking operation has been shut down for two years and had previously been operating at reduced production for several years before that, the continuous discharge of PAH-contaminated wastes, and the leaching of the Tar Pond through tidal action has, over many years, led to severe contamination of South Arm sediments and biota.

The Sydney steel plant has been a major contributor of PAHs to the local air and water.

The most elevated levels of PAH have been detected near the outlet of Muggah Creek. Levels of PAH (mostly phenanthrene, fluoranthene, benzo[a]anthracene and pyrene) in sediment and biota samples from the South Arm of Sydney Harbour were significantly in excess of typical background levels. For example, sediment values were as high as 20 times the highest values found in Boston Harbour, and South Arm lobsters were 26 times the background levels in Atlantic coastal lobsters[104]. Levels of benzo[a]pyrene in pooled hepatopancreatic samples from South Arm lobsters ranged between 387 - 2240 ng/g wet wt. (mean = 1030 ng/g), while tail muscle levels were 10 to 100 times lower (range of 8 - 43 ng/g wet wt., mean = 32.3 ng/g). Benzo[a]pyrene levels in lobsters captured in uncontaminated areas were less than 5 ng/g in hepatopancreas and barely detectable in tail muscle[105]. DFO responded to these findings in 1982 with a lobster fishing ban in the South Arm, which affected 6 boats fishing 925 traps.

Shellfish PAH concentrations here also greatly exceeded concentrations in mussels from other contaminated areas. The effect, if any, that such concentrations of PAH are having on shellfish populations in Sydney Harbour has not been studied. Although the carcinogenicity of PAH compounds has been known for some time in mammalian species, (see section 5.4) , their effects on aquatic organisms are less clear.

Concern over the vast quantity of PAH-contaminated material in the disposal area led to the commissioning of a federal-provincial study of potential options for control and/or cessation of PAH release from the Tar Pond. The preferred alternative for dealing with the Tar Pond is to excavate the material and incinerate it to destroy the PAHs[106].

Even taking into account any clean-up efforts of the Tar Pond, contamination of the inner harbour appears to be stable and long-term, and the closure of the South Arm to commercial lobster fishing is likely to continue for some time[105].

2.2.1.7 Chlor-Alkali Industry

Canso Chemicals in Abercrombie, N.S., and Canadian Industries Ltd. (CIL) in Dalhousie, N.B., are the two mercury-cell chlor-alkali plants operating in the Atlantic region, producing chlorine and caustic soda. Both plants discharge to the marine environment, with mercury being the major contaminant of concern in their liquid effluents, (as well as in their atmospheric emissions and solid wastes). These liquid effluents have been in compliance with the Chlor-alkali Mercury Liquid Effluent Regulations since 1972 (monthly averages) and on every operating day since 1977, with the exception of 14 violations at the Dalhousie plant in 1978. Loadings of mercury in these effluents have been reduced by 80% since 1972, to a 1983 combined 2-plant total discharge of less than 1 kg of mercury/month. However, the effluents remain acutely toxic to test fish, as a result of high concentrations of chlorine.

From 1963-1970, untreated mercury-contaminated brine muds were discharged from the CIL plant into the Restigouche River. These muds are now stored on site and ultimately disposed of in lined burial pits. This mercury discharge, plus that discharged in a controlled manner since then, has led to contamination of the Restigouche estuary sediments and biota in the vicinity of the outfall. Further sampling is required to determine the precise extent and degree of the contamination, but it is expected that both will show a reduction in recent years, as a result of the lower discharges of mercury.

2.2.1.8 Phosphorus Production

The Electric Reduction Co. (ERCO) phosphorus plant in Long Harbour (Placentia Bay), Nfld., was commissioned in the late 1960s. Massive kills of herring, shellfish and other marine organisms occurred in 1968 and 1969, as a result of the elemental phosphorus being discharged to the head of Long Harbour. Elemental phosphorus causes tissue destruction and internal hemorrhaging leading to death. As a result, the head of Long Harbour was closed to fishing in 1969 and 1970. ERCO then shut down operations and constructed ponds for the recycling of the contaminated process water. From 1974-1984, there has been a 70-90% reduction in phosphorus discharges, and between 1974 and 1980, ERCO was successful in bringing its effluent from continuously toxic to almost always non-toxic as a result of the improved treatment[107]. The 1970 fishery closure was reduced to an area of about 250 ha in 1977 and now only extends approximately 100 m from the end of ERCO's wharf.

2.2.1.9 Coal Mining

As discussed in section 4.2, coal development and utilization is considered to be an important element in the energy and industrial strategies of Nova Scotia and New Brunswick. With the increasing emphasis on coal as a replacement for oil, (there was a 74% increase in coal utilization in Atlantic Canada between 1978-82), the potential for environmental problems and resource use conflicts associated with its mining, preparation, transportation, utilization and waste disposal will be increased significantly. The principal noxious components of waste waters from coal mining activities are high acidity and high levels of heavy metals (particularly iron) and suspended solids[79].

It is extremely fortunate that most of the effluents from coal related activities in the Maritimes discharge directly to the sea, and not to more sensitive freshwater systems. Sea water has a high buffering capacity, which assists in rapidly neutralizing and precipitating materials from acid wastes, and limiting the impact of such wastes to the immediate area around discharge points[79].

Bridgeport Basin is a highly productive shallow tidal inlet in northeast Cape Breton, which receives the wastes from concentrated coal mining and related activities. Despite evidence of elevated levels of contaminants in some sediments, water quality in the watershed and basin is indicative of a relatively clean environment with sufficient capacity to absorb the existing pollution load[99].

Coal mining generates large quantities of waste rock which, at some sites in Cape Breton, is disposed of on the shore, to be dispersed naturally by wave action and currents. An average of 69,000 tonnes/yr of waste rock has been dumped along the shore from the Number 26 colliery for 58 years, with no apparent adverse impact. With new mines coming on line in the area however, waste rock volumes in excess of 400,000 tonnes/yr may be generated for more than half a century. More detailed studies of the possible fate and impact of these larger quantities of eroding waste rock on the local lobster and lobster habitat are presently underway.

2.2.1.10 Base Metal Industry

There are three components to the base metal industry in the Atlantic region: mining, shipping and smelting. Each presents its own set of environmental concerns, which are discussed below.

2.2.1.10.1 Mining

Base metal mining, primarily for lead, zinc and copper ores, was very active in northern New Brunswick and parts of Newfoundland in the late 1960s and early 70s, but has slowed considerably in recent years. During the mining of lead, zinc and copper ores, these metals, plus other contaminants associated with them, are released in the large volume of water associated with the mining and milling process. Metals are also released from waste rock dumps and tailings ponds at both active and abandoned mines. Many of these metals are toxic to freshwater aquatic organisms, including benthic invertebrates and anadromous fish, and impairment of stream life has occurred in waters below several mines.

Most of the metals move downstream in solution until they reach the freshwater/saltwater interface. As these metals are relatively insoluble in salt water, as compared to freshwater, the sudden drop in solubility at the freshwater/saltwater interface may result in localized high sediment concentrations in some estuaries. This is particularly obvious in Bathurst Harbour in northern New Brunswick. This watershed has been the recipient of the effluents from numerous base metal mines for many years. Dredging has been required in the main channel into Bathurst Harbour for the past 100 years, although no dredging has been permitted since 1976, due to increasing levels of cadmium, lead, copper, zinc and mercury in harbour sediments, which have built up over the last 20 years. The harbour is now rapidly silting up and commercial shipping is being phased out[108].

Table 14 lists the base metal mines operating in the region in 1982. Despite substantial improvements in the quality of their effluents, (e.g. a 60-90% reduction was recorded in zinc, copper and lead levels from the Brunswick No. 12 mine/mill to the Little River between 1974-84), most of the mines still exceed the Metal Mining Liquid Effluent Guidelines. The low pH (high acidity) in the receiving environment is of particular concern as it disrupts stream life, and may increase the toxicity of the metals present. Most benthic invertebrates, plants and fish have been eliminated from the South Little River for several kilometres below the Brunswick No. 12 mine/mill.

Continued improvement in control efforts and the slowing of the industry in this region, (due to mine closures), are expected to reduce the impacts in freshwater receiving streams and the metal loadings to coastal waters. Many of the closed sites are being carefully rehabilitated (i.e. sloped/vegetated), to reduce chronic discharges in the future.

TABLE 14
Summary of Treatment Facilities and Liquid Effluent Quality for Individual Metal Mines in 1982

Mine, (Company), Location	Products, (By-products) Rated Milling Capacity, Mining Method	Treatment Facilities	Comments on Regulations or Guidelines
Brunswick Mining and Smelting, (Noranda) Bathurst, N.B.	Zinc, lead, copper (silver) 10,000 mtpd* underground	*Brunswick No. 6* Treatment pond for acid mine water (ore shipped to Brunswick No. 12)	Exceeds Guideline for zinc, sometimes above Guideline for lead *Production suspended Dec., 1983*
		Brunswick No. 12 Tailings pond with partial recycle, treatment pond for acid mine water	Exceeds Guideline for zinc and lead, sometimes above Guideline for copper and below Guideline for pH. 60-90% reduction in Zn, Cu and Pb levels to Little River (1974-84)
Heath Steele, (Noranda) Newcastle, N.B.	Zinc, lead, copper (silver) 4,000 tpd underground	Tailings ponds, collection system for contaminated mine water	Meets Guideline *Production suspended Dec. 1984*
Buchans, (Asarco) Buchans, Nfld.	Lead, zinc, copper 1,200 tpd underground	Tailings pond	Exceeds Guideline for zinc, sometimes above Guideline for lead *Production suspended June 1982*
Consolidated Rambler, Baie Verte, Nfld.	Copper, (gold, silver) 1,200 tpd underground	Tailings pond	Exceeds Guideline for zinc, sometimes above Guideline for copper *Production suspended April 1982*
Newfoundland Zinc (Teck) Daniel's Harbour, Nfld.	Zinc, 1,700 tpd underground	Tailings pond	Meets Guideline

(Cont'd)

TABLE 14 (Cont'd)
Summary of Treatment Facilities and Liquid Effluent Quality for Individual Metal Mines in 1982

Mine, (Company), Location	Products, (By-products) Rated Milling Capacity, Mining Method	Treatment Facilities	Comments on Regulations or Guidelines
Iron Ore Co. of Canada, Labrador City, Nfld.	Iron ore 30,000 tpd pellets open pit	Partial thickening of tailings before deposit in lake, partial recycle	Does not meet Guideline
Scully (Wabush, Pickands Mather) Labrador City, Nfld.	Iron ore concentrate 16,500 tpd open pit	Tailings thickened before deposit in lake, partial recycle	Does not meet Guideline

*Note: tpd = tons per day of ore
Source: MacLatchy, 1984[109].

Mining effluents can have serious impacts on stream biota.

Several new mines are coming into operation in the region in 1985 and 1986, including the Georgia Pacific gypsum mine "Sugar Camp Lake" near Port Hawkesbury, N.S., the Rio Algom tin mine near East Kemptville, N.S., Lake George antimony in New Brunswick (reopening), several gold mining operations in Nova Scotia and New Brunswick and the St. Lawrence fluorspar mine in Newfoundland. Their environmental controls and possible environmental impacts are being very carefully scrutinized by environmental agencies before these mines are allowed to begin operation.

Acid generation from mineralized rock is another problem which occurs in many parts of Nova Scotia, and particularly around the Halifax International Airport. The airport is situated on a band of slate which, when disturbed and exposed to the atmosphere, produces acidic runoff which has adversely affected surrounding watersheds over the past two decades. Great care has been taken during the construction of recent developments on and around the airport to minimize the amount of slate that is exposed. Collection and buffering of the drainage has also substantially lessened the impact on the environment. There is still work to be done however, to overcome chronic problems associated with past activities.

2.2.1.10.2 Shipping

There are four locations in the region where base metal ores and concentrates are loaded onto ships for transport: lead/zinc concentrate is loaded at Dalhousie, N.B. (since 1964); zinc ore at Hawkes Bay, Nfld. (since 1974); lead, copper and zinc ore at Tilt Cove, Newfoundland (late 1800s to 1982) and Botwood, Nfld. (since 1950s). At each site, heavy metal contamination has resulted from the loss of ore/concentrate directly into the water by spillage, through site runoff, or through contaminated wind-blown dust.

At Dalhousie, N.B., losses of the lead/zinc concentrate to the harbour were substantial from the time loading started in 1964 until 1982. At that time efforts were taken to improve housekeeping practices, and losses were reduced to a minimum. Nevertheless, large quantities of concentrate, combined with rapid siltation from the Restigouche River and heavy loadings of organic matter from an adjacent pulp mill, created a dredging and disposal problem. There is an annual dredging requirement in this port, but levels of lead, zinc and cadmium (an associated contaminant) in the sediments have reached levels in excess of Ocean Dumping Control Act limits, thus limiting dredging and disposal options. The problem of offshore dumping has been resolved by disposal of dredged material inside a berm, where the availability of contaminants to biota is limited[110].

Total concentrations of heavy metals at three loading sites in Newfoundland were found to be elevated well beyond background levels in sediments at control sites. The mean levels of zinc, copper and lead at the three loading sites were much higher than those found at other contaminated areas in Atlantic coastal waters[111]. Nevertheless, there does not appear to be an imminent threat to humans, fish or other aquatic life at any of the loading sites in this region. Control of ocean dumping and upgraded handling methods have improved the situation greatly.

2.2.1.10.3 Smelting

Base metal ores from the Brunswick mines in northern New Brunswick are shipped to the lead smelter in Belledune, N.B., which has been operating since 1966. Cadmium, which is a waste product of the refining process, is the major contaminant of concern and large quantities of cadmium have entered the local environment through air, surface runoff and direct discharge to Belledune Harbour. As a result, Belledune Harbour and surrounding coastal waters, sediment, lobsters and blue mussels are heavily contaminated with cadmium. The high concentration of cadmium in resident lobster muscle and tomalley have made them unsafe for human consumption, despite the fact that the lobsters themselves appeared healthy. DFO closed the harbour to lobster fishing in 1980, and established a 7 km control zone around the harbour. Lobsters caught in this zone must be specially processed. Concentrations of cadmium in blue mussels are above background levels up to 20 km downcurrent of the harbour.

The lobster fishery in Belledune Harbour was closed due to high levels of cadmium.

Local environmental quality in Belledune Harbour has been improved through the introduction of an effluent collection and treatment system (November 1980), and relocation of the outfall to the outside of the harbour. Dramatic reductions of 97% in the metals discharged in the liquid effluents have been achieved since 1981. As a result, decreases in metal concentrations in lobster and blue mussels have been apparent since then, suggesting that they are responding to the reduced inputs[108]. Conditions have improved to the extent that the lobster fishery in Belledune Harbour was re-opened in 1985, under controlled marketing conditions.

2.2.2 Non-Point Sources

It is becoming increasingly apparent that point source discharges represent only a portion of the total pollution loading to Atlantic coastal waters. Non-point sources include diffuse or dispersed loadings which do not enter at discrete or identifiable locations, but which may reach the sea through rivers, or along exposed coasts.

Non-point source pollution is tied directly to existing land-use practices. In the Atlantic region, runoff from agricultural, forestry and urban areas is the major contributor to a pollution problem which cannot be controlled by the usual abatement measures applied to direct municipal and industrial discharges. Many of the impacts of this runoff are felt initially in freshwater systems, but ultimately impact on coastal waters.

Agricultural runoff is a major non-point source of pollution and the major source of sediment loading to streams and lakes[112]. In areas of intensive agricultural production such as Prince Edward Island, agricultural contaminants have the potential to severely degrade water quality and fish habitat. Agricultural runoff may contain high concentrations of nutrients, fecal coliform bacteria, and pesticides, which could contaminate surface and groundwater supplies or result in shellfish closures[112]. For example, fecal coliforms in agricultural runoff may have contributed to shellfish closures in Bedeque Bay and in the Mill and Hillsborough rivers in P.E.I.

Persistent arsenic residues in some soils have resulted from the wide use of sodium arsenite in potato fields. Lead and mercury residues in orchard soils in Nova Scotia are attributed to pesticide use[113]. Residues of synthetic pyrethroid insecticides have been detected in aquatic sediments in Prince Edward Island, and ethylene thiourea, a breakdown product of several fungicides, has been detected in soils[114]. The herbicide atrazine has occasionally been detected in the Annapolis — Cornwallis River systems in Nova Scotia, but pesticides were not detected in a similar study of the Saint John River[115].

There is also some concern, (but no field data as yet) about the potential effects of other pesticides such as endrin, carbofuran and azinphos-methyl in agricultural runoff. (See section 3.2.3 for a discussion on fish kills and other problems associated with the use of agricultural pesticides).

Urban runoff, or runoff contaminated by street dusts or deposits, has been identified as a significant source of hydrocarbons and nutrients to aquatic ecosystems. For example, the total annual input of hydrocarbons to Halifax Harbour from urban runoff may be up to 15 times greater than the input from the Imperial Oil refinery. In addition, metal concentrations from runoff collected at a parking lot in Dartmouth, N.S.,[116], were higher than for those from raw domestic sewage entering a treatment plant located nearby at Eastern Passage. Trace concentrations of aluminum, iron, potassium, sodium, magnesium, lead, calcium and titanium were all found in street dusts in Halifax[117].

Forestry is another major contributor of sediment and pesticides. Clearcutting exposes extensive areas of forest to rapid erosion and it is only recently that vegetated buffer strips are helping to reduce the siltation of adjacent watercourses. Recent efforts to restrict the movement of heavy equipment across streams is also lessening the amount of sedimentation. In urban areas, sediment, metals and organic matter readily run off the land due to the reduced infiltration and collection of this runoff in sewers.

All of these land-use practices result in siltation of streams, lakes and estuaries and introduce toxic metals and organics which can destroy fish habitat, and reduce dissolved oxygen levels. These effects may result in fish kills (or other chronic effects), reduced productivity, impaired recreational use and shellfish closures in coastal areas.

2.2.2.1 Shellfish Closures

One regionally based and consistent indicator of the biological quality of nearshore waters is provided by the shellfish pollution monitoring program. As of 1983, there were 262 shellfish growing areas in the Maritime Provinces closed to harvesting (25 of these closed since 1979), comprising a total surface area of approximately 140,000 ha[118] (Figure 20). Although no complete region-wide assessment has been made of what percentage of the available shellfish growing areas in the Maritimes this represents, a recent survey by DFO indicated that about 22% of the soft-shell clam flats in the Scotia-Fundy region were closed[120]. The steady increase in the number of shellfish growing area closures since 1940 (Figure 21) is a reflection of both increasing fecal contamination from point and non-point sources and the increased surveillance efforts by the federal government.

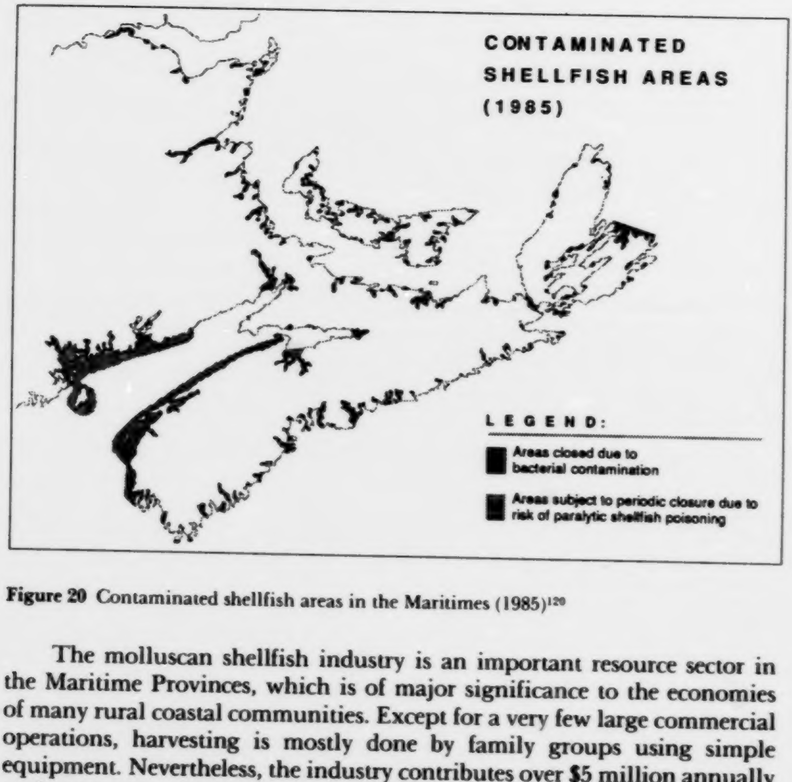

CONTAMINATED SHELLFISH AREAS (1985)
LEGEND:
Areas closed due to bacterial contamination
Areas subject to periodic closure due to risk of paralytic shellfish poisoning

Figure 20 Contaminated shellfish areas in the Maritimes (1985)[120]

The molluscan shellfish industry is an important resource sector in the Maritime Provinces, which is of major significance to the economies of many rural coastal communities. Except for a very few large commercial operations, harvesting is mostly done by family groups using simple equipment. Nevertheless, the industry contributes over $5 million annually to the economy, through the harvesting of oysters, clams and mussels from Atlantic coastal waters. Table 15 shows the annual landings in the three Maritime Provinces during 1978-1982. The commercial harvesting of shellfish in Newfoundland has not yet been quantified[118].

Although there is little commercial harvesting of shellfish in Newfoundland at the present time, a 5-year survey to determine the areas of Newfoundland's coastline which are safe for shellfish harvesting was initiated by EPS in 1984. An inventory was conducted to classify the size and location of Newfoundland's recreational and commercial harvesting areas, which is being followed by comprehensive bacteriological and sanitary quality studies of identified harvesting sites. In 1983, EPS recommended the first shellfish closure for Newfoundland. Surveys will continue over the next four years of the program until the entire province is covered[122,123].

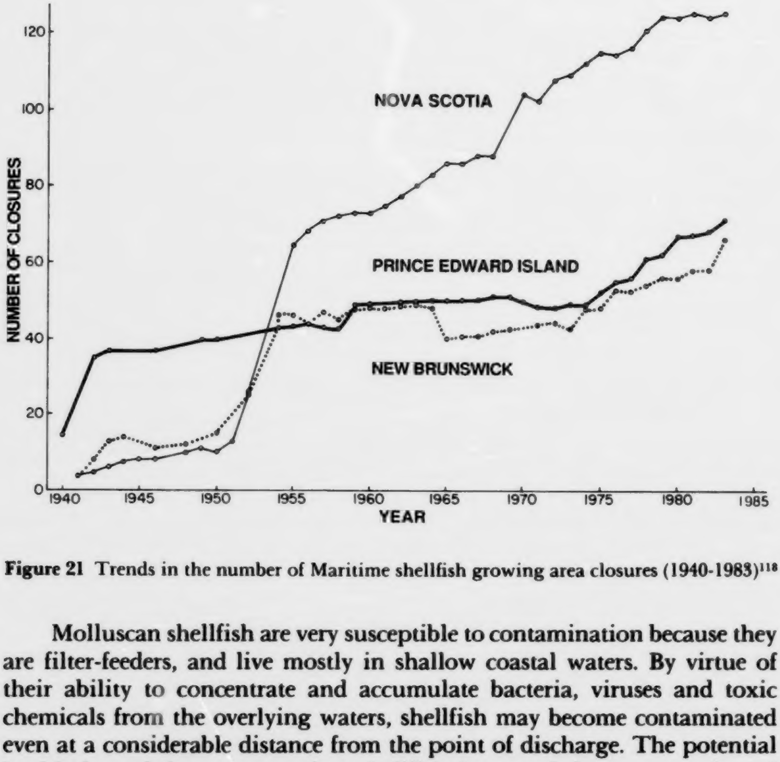


Figure 21 Trends in the number of Maritime shellfish growing area closures (1940-1983)[118]

Molluscan shellfish are very susceptible to contamination because they are filter-feeders, and live mostly in shallow coastal waters. By virtue of their ability to concentrate and accumulate bacteria, viruses and toxic chemicals from the overlying waters, shellfish may become contaminated even at a considerable distance from the point of discharge. The potential health hazard from consuming shellfish harvested from contaminated waters is particularly high because shellfish are often eaten raw or partially cooked. (See also the Section on Human Health and the Environment). In Canada, no major outbreaks of enteric diseases have been attributed to shellfish harvested from "approved" growing areas in the past ten years[118].

Shellfish growing areas must be approved prior to harvesting shellfish for human consumption. In the Maritimes, these are classified as "approved", "conditionally approved" or "prohibited", on the basis of the sanitary and bacteriological water quality conditions of the area. (Areas are closed if there are greater than 14 fecal coliform bacteria per 100 ml of water). Some of the shellfish closures which are caused by runoff from agricultural land tend to be seasonal, as well as being regulated by the intensity and duration of the rainfall which occurs. The area may be open for shellfish harvesting during dry weather, but after a given intensity and duration of rainfall (0.5 or 1.0 inches in 24 hours), the area is closed for a specified period of time (usually 7 days). (This area would be designated "conditionally approved").

TABLE 15
Maritime* Shellfish Landings and Values, 1978-82

Year	Clam		Oyster		Mussel	
	Metric Tonnes	Value ($'000)	Metric Tonnes	Value ($'000)	Metric Tonnes	Value ($'000)
1978	3889	1603	1483	983	116	28
1979	3695	1641	1482	1151	40	16
1980	4254	2340	1514	1444	189	89
1981	4722	2846	1403	1524	173	86
1982	6230	3910	1321	1324	192	122

*Maritime Provinces include Nova Scotia, New Brunswick and Prince Edward Island. No commercial shellfish landed value for Newfoundland. These figures represent only transactions through known bulk shellfish buyers; they do not include sales by local harvesters or recreational diggers.

Source: Department of Fisheries and Oceans, 1983[121].

Shellfish growing areas may also be closed to shellfish harvesting because of the presence of naturally occurring paralytic shellfish poison (PSP), produced by the dinoflagellate *Gonyaulax excavata.* This organism "blooms" in warm weather to create what are called "red tides." When the red tide washes the bivalve beds, the shellfish strain the organisms from the water in great numbers, accumulating the poison. (See also the section on Human Health and the Environment). The Bay of Fundy coast is periodically closed to shellfish harvesting during the summer months because of the presence of PSP (Figure 20), and several cases have also been identified in Newfoundland waters. PSP is a worldwide phenomenon, affecting all shellfish-producing countries.

The impact of shellfish closures has not only resulted in the loss of millions of dollars to the fishery in certain areas, but has also produced serious social problems in some areas such as unemployment, decline in tourism and higher prices to shellfish consumers. The adverse economic impact of coastal pollution on the local shellfish industry is best illustrated at Caraquet Bay in northeastern New Brunswick, which is one of the most productive oyster growing areas in the Maritimes (producing 70% of the New Brunswick catch). At present there are approximately 2,400 ha of water in Caraquet Bay closed to the harvesting of shellfish for direct marketing because of fecal contamination. The present commercial shellfish harvesting in the bay is estimated at $500,000. If the pollution problems in the bay were eliminated, the annual production of oysters could increase to $2 million[118]. It is encouraging to note that the sewage treatment plants in Caraquet, which have never operated adequately, were replaced by a new system in 1983. The size of the shellfish closure has, however, only been slightly reduced to date.

2.2.3 Physical Degradation

The construction of causeways, dams, breakwaters or piers can result in the degradation of sensitive coastal ecosystems. This degradation is often due to changes in circulation patterns which ultimately alter oceanographic parameters such as temperature, salinity and sedimentation rates. These changes, in turn, affect biological communities. For example, the construction of the Canso causeway has changed benthic species composition in St. Georges Bay and the Strait of Canso. A smaller causeway at Barrington Passage, N.S., has cut off a summer mackerel migration route and has resulted in the smothering of lobster habitat. The causeway at Windsor, N.S., and a breakwater in Saint John harbour, N.B., have resulted in extensive sedimentation and the displacement of benthic communities.

The impact of construction activities is felt most strongly in estuaries and saltmarshes. The Maritime Provinces contain over 525 estuaries greater than 1 ha in size, an average of about one estuary for every 13 kms of coastline[124]. Associated with these are extensive saltmarshes. Some of the early settlers of this region began to dyke the marshes to reclaim the land for agricultural purposes. It has been estimated that about 80% of all marshlands in the Maritimes have been reclaimed at one time. Today 65% remain dyked, leaving only 20,000 hectares of natural saltmarshes in the three Maritime Provinces. (No data is available for Newfoundland). Nova Scotia, in pre-settlement days, yielded over 28,000 ha of natural saltmarsh. This figure is now reduced to 12,370 ha[125]. Today, urban and industrial development contribute more to decreasing acreage of saltmarsh than agricultural use does. With such development comes increasing pressure from insecticides, oil spills and siltation, resulting in disruption of circulation, reduced oxygen content, and lowered productivity.

A recent attempt to build a highway directly across the highly productive and intensively utilized 1,100 hectare Chezzetcook saltmarsh outside of Halifax was averted following strong opposition from Environment Canada, DFO and local citizens. The highway will still be built, but at the inland extremity, leaving the largest part of the saltmarsh untouched.

2.2.4 Cumulative Impacts

Problems of physical degradation are magnified when combined with multi-point source pollution in embayments such as industrialized ports and harbours. Each input or activity on its own may not have a measurable or deleterious impact, but a cumulative impact may result which permanently changes the appearance, productivity and use of a coastal area. Examples of the impacts of concentrated industrial activity have already been discussed for such places as Dalhousie, Belledune and Sydney. Similar problems have occurred in the Strait of Canso, Saint John harbour and in the L'Etang estuary in southern New Brunswick.

The Strait of Canso is an area of concentrated industrial activity located between Cape Breton Island and the mainland of Nova Scotia. Anthropogenic sources of contamination include an aggregates loading facility, a gypsum wharf, pulp mill, thermal power plant and oil refinery (inactive since 1980). Vessel traffic related to offshore exploration activity has also increased in the last few years. A 1983 survey of the Strait demonstrated the continued extension of a molluscan barren zone (along the eastern side of the Strait south of the causeway) through a previously diverse area of the Strait. This was paralleled by an order-of-magnitude decrease in the average density of polychaetes between 1969 and 1983. There is also a trend of higher metal and organochlorine concentrations in the Strait sediments, compared with those from the mouth of Chedabucto Bay (62 km out)[126], and south along the essentially clean Eastern Shore of the mainland.

The combined effects of physical and chemical stress on a coastal system are particularly apparent in Saint John, N.B. Saint John is an industrialized port on the Bay of Fundy which has been the centre of a recent controversy with the fishing community. The fishing industry, which has known a long and prosperous history in the Saint John area, has been experiencing accelerating declines in success and a loss of vital fish habitat, particularly during the past 10-20 years. Sources of contamination affecting the harbour include an oil refinery, two pulp and paper mills, a sugar refinery, ship building facilities and municipal discharges. Associated activities include dredging and ocean dumping, wharf and breakwater construction and infilling.

Much of the focus of concern has been on increasing siltation in the Bay, considered to be the result of disposal of dredge spoils. However, these impacts were found to be minor and it has become reasonably clear that it is the cumulative impacts of the many development activities in the harbour and along the Saint John River that have had an incremental effect on the fish stocks and landings in the area[127].

Environmental problems began in the L'Etang estuary in southern New Brunswick when a causeway was built directly across the estuary in 1967, which separated the upper and lower portions and reduced water exchange. In 1971, the Lake Utopia pulp mill began discharging to the upper portion of the estuary. This combination of inappropriate site selection and inadequate waste treatment at the mill rapidly resulted in the depletion of dissolved oxygen levels in the upper half of the estuary, which progressed to the lower portion within a year. This problem continues still.

Scallop catches in the estuary began to decline, and in 1973, the very productive commercial soft-shell clam fishery (which formed 6-13% of the New Brunswick total) was closed to harvesting. The herring weir fishery was failing in the estuary and there was a shift in the composition of benthic communities from filter feeders (high food value) toward deposit feeders (no commercial food value). By 1976, bottom waters in a one kilometre stretch of the lower section of the estuary were anoxic and severe oxygen depletion extended over 3 km below the causeway. By 1980, approximately 8 km of the 14 km long estuary could be considered directly affected. Of almost 50 benthic species commonly found in the area, only 4 were found in 1977 in the 5 km stretch below the causeway. There is also evidence that fish may be avoiding the area, either due to the non-availability of food, or the inhibitory effect of the water-borne pollutants.

Despite considerable effort by federal and provincial authorities to reduce pollution from this mill, both BOD and suspended solids discharges remain out of compliance. After over a decade of pollution, the L'Etang estuary remains a problem.

2.3 Offshore Water Quality

Any discussion of the Atlantic region must include the vast area of the Northwest Atlantic ocean, which is as much a part of this region as the land. Ocean areas off Atlantic Canada include the Bay of Fundy-Gulf of Maine, the Scotian Shelf, Grand Banks, Gulf of St. Lawrence and the Labrador Sea (Figure 17). The main uses of the eastern Canadian offshore are for fishing and transportation and more recently for hydrocarbon development. Specific data and information on this segment of the marine environment are not easy to obtain and are frequently difficult to interpret, resulting in many gaps concerning the ecological effects of contaminants in offshore waters and unanswered questions regarding the quality of the offshore environment.

Sources of contamination include atmospheric deposition, discharges from rivers and shore-based industries, offshore discharges from hydrocarbon exploration activities and the routine discharges and occasional oil spills from ships. All of these may adversely affect the quality of the offshore environment, with adverse effects on marine mammals, birds, fish and their dependent food species. Commercial fishing in particular is dependent on a satisfactory level of environmental quality. Abnormally high levels of pollutants could not only threaten the viability of fish stocks, but could lead to the accumulation of contaminants which

TABLE 16
Contaminants Affecting Offshore Water Quality in the Atlantic Region

Type of Contaminant	Sources	Observed Effects	Status
Petroleum Hydrocarbons	Land-based sources, atmospheric deposition, marine transport (operational and accidental discharges), drilling platforms	Background levels are well below those known to have adverse effects on most marine life. Seabirds susceptible to acute and chronic events.	Near pristine conditions. Short-term elevations (L 1 yr) after acute events. Indications of a general decline in background levels.
Organochlorines	Atmospheric deposition, river runoff	Levels in water and marine biota are 100 to 1000 times lower than concentrations which would kill marine biota. Sublethal effects can be detected. Most levels in fish are well below public health regulatory limits.	Region is relatively contaminated by DDT and less so by PCB in comparison to areas in western Europe. DDT levels declining in marine biota, PCB levels declining much slower.
Heavy Metals	Atmospheric deposition, river runoff	No identifiable effects in offshore organisms.	Offshore waters remain essentially unaffected by metals.
Drilling Muds	Drilling platforms	Smother biota in the immediate vicinity of the platform. Oil-based muds cause lethal and sublethal responses in organisms from long-term exposures.	Use of oil-based muds is expected to increase.
Persistent Litter	Shore-based sources, wastes discarded at sea	Aesthetically unpleasing. Impairment of recreational uses of coast. Ingestion by, or entanglement of marine birds and mammals. Hazard to beach visitors, fishermen and ships.	Use of persistent material such as plastic is expected to increase the presence of persistent litter in the Northwest Atlantic.
Chemical Explosives	Seismic exploration	Suspected impacts on marine fish, birds and mammals.	Limited application in the Atlantic region. Impacts still being investigated.

would restrict the sale of fish or fish products for human consumption. The important contaminants are listed in Table 16 and their significance to the environmental quality of offshore waters is discussed below.

2.3.1 Petroleum Hydrocarbons

The estimated range for the total worldwide input of petroleum to the marine environment from all sources is between 1.7 and 8.8 million tonnes per annum (mta), with a best estimate of 3.2 mta. This input can be divided about equally between land-based and sea-based sources (Table 17). Approximately 39% of the petroleum hydrocarbons entering the marine environment result from oil and gas production and transportation. However, more than 45% originates from other shipping activities and from industrial, municipal, urban and river runoff. Although the amount of petroleum and petroleum products transported by sea, as well as crude oil produced offshore, has increased during the past 8 years, petroleum hydrocarbon input to the marine environment does not appear to have followed this trend[128].

Although most of the world's oceans contain only trace levels of petroleum-related substances, surface pollution in the form of slicks and floating tar particles is generally elevated in the major tanker routes and shipping lanes. Since less than 1% of the total world tanker traffic passes through Candian waters between the Canada/U.S. border and Hudson Strait, and because the surface waters in this region are dominated by the southward flow of unpolluted Labrador Current water, surface contamination in this region remains at levels much below those further south[129].

During the early 1970s, the level of tar pollution in the Canadian North Atlantic was virtually undetectable, while in the southern part of the North Atlantic the level was about 160 $\mu g/m^2$. This situation still exists, despite the activity of oil exploration and several major tanker incidents off the east coast of Canada. Following both the Arrow and Kurdistan oil tanker spills, concentrations of dissolved/dispersed petroleum residues on the sea surface and in the water column increased drastically, but returned to background levels within a few months after the input ceased. All evidence of oil remaining from the Kurdistan spill in 1979 had disappeared from the offshore waters of the region within a year, due to the effectiveness of the local current system in transporting surface oil from the region[129]. Nevertheless, sedimented oil residues remain today in certain areas of the bottom and along some sheltered stretches of shoreline.

Background levels of petroleum hydrocarbons throughout the Northwest Atlantic are well below those known to have adverse acute effects on most marine life. Similarly, concentrations seem to be below those that have been demonstrated to have low-level, long-term effects. Recent data also confirm a decline in the background levels of dissolved/dispersed petroleum residues in the Gulf of St. Lawrence and on the Scotian Shelf throughout the 1970s. The situation in the region has improved to the point where offshore waters can be considered to be essentially uncontaminated as far as petroleum residues are concerned[129].

TABLE 17
Worldwide Input of Petroleum Hydrocarbons into the Marine Environment
(million tonnes per annum (mta))

Source	Probable Range	Best Estimate[a]
Natural Sources		
Marine seeps	0.02 — 2.0	0.2
Sediment erosion	0.005 — 0.5	0.05
(Total natural sources)	(0.025) — (2.5)	(0.25)
Offshore Production	0.04 — 0.06	0.05
Transportation		
Tanker operations	0.4 — 1.5	0.7
Dry-docking	0.02 — 0.05	0.03
Marine terminals	0.01 — 0.03	0.02
Bilge and fuel oils	0.2 — 0.6	0.3
Tanker accidents	0.3 — 0.4	0.4
Non-tanker accidents	0.02 — 0.04	0.02
(Total transportation)	(0.95) — (2.62)	(1.47)
Atmosphere	0.05 — 0.5	0.3
Municipal and Industrial Wastes and Runoff		
Municipal wastes	0.4 — 1.5	0.7
Refineries	0.06 — 0.6	0.1
Non-refining industrial wastes	0.1 — 0.3	0.2
Urban runoff	0.01 — 0.2	0.12
River runoff	0.01 — 0.5	0.04
Ocean dumping	0.005 — 0.02	0.02
(Total wastes and runoff)	(0.585) — (3.12)	(1.18)
TOTAL	1.7 — 8.8	3.2

[a] The total best estimate, 3.2 mta, is a sum of the individual best estimates. A value of 0.3 was used for the atmospheric inputs to obtain the total, although it is realized that this best estimate is only a centre point between the range limits, and cannot be supported rigorously by the data and calculations used for the estimation of this input.

Source: U.S. National Research Council, 1985[129].

Nevertheless, seabirds are often not able to tolerate any exposure to oil from either acute or chronic discharges. Many birds can and have been killed during major oil spills, and many oiled birds wash ashore in Newfoundland and around Sable Island, particularly during the winter months, suspected victims of routine tank cleaning by passing ships.

2.3.2 Organochlorines

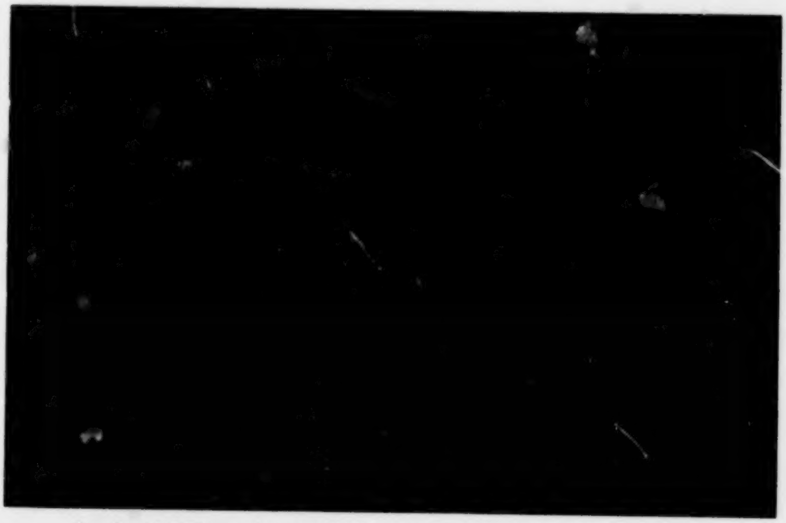
The compounds in this class are produced exclusively by manufacturing, but may be changed slowly by natural processes in the environment. The DDT group of insecticides and PCBs are the most common organochlorines in the western North Atlantic. The potential environmental and health hazards attributed to organochlorines have resulted in a marked decline in the use of this class of chemical over the past 10-15 years. The largest use of DDT in eastern Canada was in the New Brunswick forest spray program. From 1952 to the late 1960s, DDT was sprayed in amounts up to a maximum of about 6×10^6 kg annually. Some of the DDT found in the Northwest Atlantic ecosystem undoubtedly comes from this source, either by atmospheric transport or by river discharge[130]. For example, it is estimated that about one-quarter of the DDT sprayed over New Brunswick in 1968 was carried to the Gulf of St. Lawrence by atmospheric transport[131]. Both atmospheric transport and river discharge could also have transported DDT from other areas such as the Great Lakes Basin.

PCBs, another member of this class of substances, have had only a small scale and local industrial application in eastern Canada: on the other hand, they were components of a wide variety of consumer products (e.g. hydraulic fluids, pressure sensitive copying paper, paint additives) whose disposal was not adequately controlled. (See section 3.1.2.1). Because of this, and because they are easily transported in the atmosphere from other areas where they might be more widely used, they seem to be distributed fairly generally throughout the marine environment of eastern Canada[130].

Organochlorine compounds are very insoluble in water, but generally soluble in lipids (i.e. fats). They are therefore readily adsorbed to and reluctantly desorbed from small particulate material in the sea, and also tend to concentrate at the lipid-rich surface microlayer of the ocean (usually the top few hundred microns). Typical DDT concentrations in surface waters (excluding the microlayer) range from about 0.1 to 10 ng/L. PCB concentrations in the same medium are about 10 times higher (approx. 1 to 100 ng/L). Concentrations of both residues in the microlayer may be about 5 times higher again[130].

Relatively few data are available describing offshore sediment organochlorine concentrations in eastern Canada, but in general, marine sediments are reported to contain up to 50 ng/g for both DDT and PCBs[130]. Concentrations of organochlorines in bivalve molluscs in this region vary around 0.02 µg/g wet weight, which is at the lower end of the range of values reported during the U.S. National Shellfish Monitoring Survey, and lower than some of the values reported for more obviously contaminated industrial areas[130].

Residues of either PCBs or DDT in finfish in this region range widely from about 0.01 to approx. 5.0 µg/g wet weight. Concentrations of DDT in Northwest Atlantic cod livers were similar to those found in the North Sea (near the high end of the range), while PCB levels in eastern Canadian fish (intermediate in the range) were higher than those found in Arctic samples, but lower than those found in the southern North Sea where there are major industrial inputs[130]. Canadian herring samples show that typical DDT levels are usually below 0.5 µg/g wet weight, about intermediate in the range of levels found in the Baltic Sea. Levels of PCB and DDT in the livers of cod caught off Halifax appear to have declined throughout the 1970s[132].



Levels of DDT in seals on Sable Island have declined since the early 1970s.

Organochlorine residues in seals in eastern Canada are generally about ten times higher than those from the uncontaminated Canadian Arctic, but about 100 times lower than those from the highly contaminated Baltic Sea. DDT insecticide residues in the blubber of grey seals on Sable Island in 1982 were lower than comparable samples taken in 1974 and 1976, and p,p'-DDE (a metabolite of DDT) represented a greater fraction of total DDT. Concentrations of PCB residues did not change over this period[133].

This is the first clear indication that DDT group residues in high trophic level marine biota have responded to the DDT ban of the early 1970s. PCBs are more resistant to degradation than are the DDT group and this, together with a slower reduction in the rate of input, may explain why PCBs persist at low and intermediate trophic levels while the DDT declines. Harp seal data suggest that some reduction in PCB concentrations at high trophic levels may occur, though only over relatively long intervals[133].

The organochlorine levels which are currently found in water or marine biota in Atlantic Canada are at least 100 and more often 1,000 times lower than concentrations which would kill aquatic biota. Less acute biochemical effects can, however, be detected. These can be brought about by levels of some contaminants, especially PCBs, now found in some local marine fish. Although sublethal effects can be detected at the organization level of enzymes or biochemical processes, it is difficult to show that they have any effect at the whole organism, population or community level.

Concerning the public health aspect, most organochlorine levels in Atlantic Canadian fish and fishery products are well below the current tolerances established by the regulatory agencies (2 μg/g for PCBs, 5 μg/g for DDT — both as wet weight of the edible portion). Only in the cases of very large or relatively old fish (e.g. swordfish and tuna), does it appear likely that these tolerances could be exceeded[130].

Another widely used organochlorine which is ubiquitous in the marine environment is the insecticide toxaphene. Introduced in the mid-1940s, U.S. production figures in 1980 showed that twice as much toxaphene is being produced as was DDT in its peak years before being banned. It is still in widespread use in the U.S. and represents the single most used pesticide on a weight basis. Toxaphene moves readily through the environment, is extremely persistent, bioaccumulates, and is acutely and chronically toxic to various fish species. Levels have been recently reported in herring, cod and tuna off the east coast[134], but there are too few data describing its occurrence to allow any inference of spatial or temporal trends in its distribution at this time.

Reported levels of non-halogenated synthetic organic chemicals (phthalic acid esters, organophosphates, aromatic amines, organotins, organic arsenicals) in the Northwest Atlantic appear to be considerably less than concentrations of PCB and DDTs. No environmental problems which might be attributed to such materials have been documented[135].

2.3.3 Heavy Metals

The concentrations of metals throughout the marine waters of the western North Atlantic, in the Gulf of St. Lawrence, and in most Atlantic coastal areas do not vary widely. Regions of localized metal contamination do occur in some coastal locations such as Belledune Harbour in northern New Brunswick where a lead smelter operates, but these are not extensive and have no profound effects on the greater marine environment[136].

Although Belledune Harbour is one of the most heavily contaminated coastal areas in the region, concentrations of metals above background in marine waters, sediment and biota extend for only a few kilometres from this source[108]. Although various marine organisms can accumulate metals from their surroundings, the levels of metals in marine species in the western North Atlantic have generally not been elevated by human activities[136].

2.3.4 Drilling Muds

Drilling fluids or muds are a major effluent from offshore hydrocarbon exploration activities, which have both physical and chemical effects on benthic communities in the vicinity of rigs. They are complex mixtures of clays and chemical additives, that are used in drilling operations to equalize hydrostatic pressure, remove drilled cuttings and lubricate the drill bit. They consist of oil or water- based suspensions of some mineral such as barite, with additives such as detergent or emulsifiers. Drilling fluids along with drill bit cuttings are continually discharged to the surrounding waters during the drilling operation and are discharged in bulk at the completion of a well or during a major change in the drilling fluid program[137]. Approximately 800-1,500 m^3 of cuttings are discharged per development well[138].

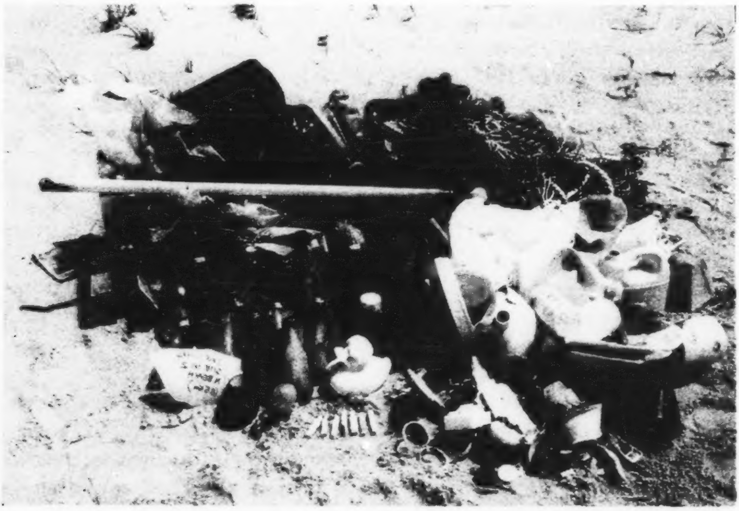
Drilling muds originally used offshore in eastern Canada were water-based, because the diesel oil-based muds used elsewhere were toxic to many marine organisms. More modern and much less toxic oil-based muds are now more commonly being used in this region.

Discharges of cuttings from water-based and oil-based drilling muds have an adverse effect on seabed biological communities beneath and in the immediate vicinity of the platform (within 500 m), mainly due to physical burial under the mound of cuttings on the seabed. Beyond the area of physical smothering is a "transition zone" (generally 200 to 1,000 m), in which subtle chemically induced biological effects can be detected[139]. The greatest concern with the oil-based muds is the toxicity to the early life stages of marine organisms[138,140,137].

Approximately 200 exploration wells had been drilled off eastern Canada by the end of 1984.

2.3.5 Persistent Litter

Apart from oil pollution, persistent litter is one of the only kinds of marine pollution that is readily visible in the marine environment. Because of this, the "health" of the oceans, as perceived by the ordinary individual, often varies according to the amount of floating or stranded litter seen at sea or along the coast. Despite the high visibility of litter in the sea, its importance in relation to other contaminants is low[141].



Persistent litter is showing up with increasing frequency in the marine environment.

Persistent litter can be defined as any artificial material that enters the marine environment which is resistant to rapid degradation or breakdown. Materials such as plastics, metals, glass and nylon are most prominent. These materials are showing up in the marine environment with increasing frequency. Persistent litter contaminates the ocean by floating at or near the surface, or by sinking and cluttering the sea floor. Its final fate is often to come ashore, thereby fouling shorelines and beaches.

The increased use of plastics in wrappings, containers and disposable items; the development of fishing nets and ropage made from plastic products such as polypropylene; the careless discharge of garbage from ships at sea and from urban centres along the coast and the increased use of marine waters for recreation, have all contributed to the increasing presence of persistent litter in the marine environment. The fishing industry is probably one of the major offenders. There is also considerable evidence that debris lost or discarded by the oil industry in exploration, drilling and well production has created problems for shipping and fishing, particularly in the North Sea, where these activities are concentrated[141]. This being the case, the Canadian Atlantic offshore may become increasingly contaminated by materials such as drill heads, pieces of steel piping, wire and hawsers, empty drums and paint cans, as our offshore hydrocarbon development increases.

Materials recently collected in a survey of the beaches of Sable Island include: nylon fish nets and ropes; floats and buoys; plastic six-pack strappings, bags, milk crates and buckets; glassware; light bulbs; tin cans; metal drums; rubber hose; hardhats; styrafoam; garbage bags and tampon holders[142].

Aside from the aesthetic considerations, entanglement of marine mammals and birds seems to be one of the most serious environmental problems arising from litter in the oceans. Seals trailing netting, fishing line, or girdled by plastic straps have become common occurrences in some ocean areas. Although only a few such incidents are noted during yearly seal counts on Sable Island, unknown numbers are no doubt fatally entangled and die of drowning, malnutrition, or from wounds inflicted by the entangling material cutting into their flesh.

Marine litter is both unaesthetic and annoying and leaves the impression of reduced quality of the open ocean and decreased recreational enjoyment of the shorelines. Litter such as pop can tops, broken glass and rusty nails can cause cuts or injuries to human visitors to beaches. Floating or sunken debris can also present serious or nuisance hazard to ships and mariners, through entanglement of gear, fouling of propellers or blockage of cooling water intakes[141].

2.3.6 Chemical Explosives

During exploration for offshore hydrocarbon reserves, geophysical information is provided by seismic reflection surveys. Chemical explosives may be used to provide the seismic "pulse". These high energy explosions in near surface waters (the smallest of which is equivalent to several sticks of dynamite) raise the concern for potential biological impact on fish, birds and marine mammals.

A recent study using the linear explosive "AQUAFLEX" was conducted in the shallow waters (L 15 m) off Sable Island. The concern here centred on the major concentrations of juvenile haddock in the area. During this seismic survey, more than 1,000 shots were made on seismic lines of nearly 55 km in length. More than 10,000 fish were killed (estimated biomass of less than 1 tonne), the majority of which died in a narrow band of 10 m on either side of the shot. The major injury was through the rupture of the swim bladder[143]. Although the impacts were reported to be minimal, nothing can be said at this time of any impacts on marine birds or mammals. Nevertheless, most seismic exploration is completed off the east coast and the use of chemical explosives is diminishing.

2.3.7 Transport of Contaminants

Atmospheric deposition, river discharge and shore-based industries represent the major entry routes of contaminants to the eastern Canadian offshore. Other sources such as discharge from ships and the offshore oil and gas industry are of less general significance[144], as is the case in the North Sea[145].

Atmospheric transport appears to be the major source of contaminant input to the Northwest Atlantic. Most storms in the North Atlantic pass through the highly industrialized regions of North America, where they pick up contaminants and subsequently deposit them in the North Atlantic[144]. The bulk of the water circulating around the Scotian Shelf and Gulf of St. Lawrence comes from "outside" the region, with less than about 5% of the water identifiable as river input. Since freshwater runoff represents such a relatively minor input to the western North Atlantic, and since pollutant concentrations in that runoff are generally low (with a couple of exceptions), river input does not represent a major source of pollutants to the area[146]. The impacts of shore-based industries, ocean dumping and marine disposal are widely separated on the east coast and their effects are identifiable for only a few kilometres from their sources.

Chapter 3
Toxic Chemicals

Summary

Toxic chemicals such as mercury, cadmium, lead, arsenic, PCB, dioxins and PAH are widely distributed throughout the Atlantic region, but generally at concentrations where adverse environmental effects are unlikely. There are, of course, exceptions to this statement. Mercury and PCBs occasionally exceed Health and Welfare Canada guidelines for concentrations in fish, particularly in larger, older fish from parts of Labrador, the Saint John, Annapolis, Shubenacadie and La Have rivers and from marine waters. Cadmium concentrations exceeding the Ocean Dumping Control Act limit in sediment are relatively common, particularly from harbours in northern New Brunswick. Fortunately, some point sources of metals, such as chlor-alkali plants and the Belledune smelter have significantly reduced emissions and effluents. In spite of substantial reductions in lead emissions from automobiles, ambient levels in larger cities are still of concern. Other health and environmental concerns include arsenic contamination of well water, and excessive PAH emissions from the Sysco coke ovens.

The number of pesticides registered for use in Canada has steadily grown from 400 in 1979 to 514 by the beginning of 1985. A new formulation of aminocarb is being produced which is both effective at controlling the spruce budworm and at the same time has resulted in few adverse impacts on non-target organisms. Glyphosate is beginning to replace 2,4-D and the more controversial 2,4,5-T as the preferred forestry herbicide. Large quantities of agricultural pesticides are still being used in the Atlantic region. This has led to some contamination of well-water in New Brunswick and of estuaries in Prince Edward Island. The problem of pest resistance is also attributed to heavy use of pesticides. One part of the solution is integrated pest management, which incorporates new cropping practices with biological controls, natural predators and a lesser reliance on

chemical pesticides. Fish kills from pesticide misuse have been reduced in the region through the adoption of provincial regulations or guidelines prohibiting the loading of spray equipment near watercourses.

The Atlantic region generates approximately 5% of the hazardous wastes in Canada. The total generated in the region in 1984 was slightly higher than that generated in 1979. There is as yet no systematic or comprehensive approach to the problem of hazardous waste management; most wastes are disposed of on a case-by-case basis, some employing questionable practices. Recycling and waste exchanges are options which could be better utilized by waste generators in the region.

Numerous spills have resulted from the improper storage and transportation of dangerous goods. The total annual number of spills reported to EPS has slowly increased since 1979, but the total number of larger, or significant spills, has decreased. The transportation of toxic substances, including hazardous wastes, is regulated by the Transport of Dangerous Goods Act. Provisions under the Act should help to reduce spills, result in a more efficient response to emergencies, and produce a better understanding of the traffic patterns associated with the movement of these goods.

3.0 TOXIC CHEMICALS

Nearly all chemicals can be toxic under some conditions. Those chemicals which in small quantities could pose a threat to natural ecosystems or to human health and well-being are of major concern. These contaminants are often resistant to natural degradation (persistent) or can accumulate in an organism's tissue (bioaccumulation). Highly toxic chemicals such as dioxins are capable of causing biological changes at extremely low, or trace levels (i.e. in the parts per trillion range). Many toxic chemicals are generally irretrievable once released into the environment and adverse effects may be irreversible[147].

3.1 Chemicals of Concern

The chemicals discussed in this section have been identified as being of particular concern in the region. Although they are distributed in air, water, sediments and biota throughout the region, they are primarily of concern in specific locations where elevated levels and adverse impacts have been noted. These chemicals have been more closely investigated than others in the region, although much still remains to be learned about their potential environmental impacts.

3.1.1 Metals

3.1.1.1 Mercury

Mercury is an ubiquitous, silver-white, liquid metal which is widely recognized as one of the most toxic environmental pollutants occurring in the environment. Mercury fulfills no known biological function, and its presence at even slightly elevated levels is not tolerated by most biota.

TABLE 18
Mercury in the Atlantic Provinces

Medium	Background Levels	Elevated Levels	Guidelines or Regulated Limits
Air	0 — 15 ng/m^3	2,550 ng/m^3 (max. 2 hr. conc. Dalhousie, N.B.)(1)	2000 ng/m^3 (Ontario MOE 24 hr. air quality criteria)
Water	0.01 µg/L (fresh) 0.05 — 0.07 µg/L (coastal seawater)	0.06 — 0.38 µg/L (LaHave river estuary) 0.23 µg/L average (Saint John r.)	0.0041 (U.S. EPA Water Quality Criteria for Aquatic Life)
Sediments	L0.10 µg/g (aquatic sediments) 0.02 — 0.15 µg/g (soils)	8.1 µg/g (Dalhousie, N.B.)(2) 4.1 µg/g (Eddy Pt., N.S.)(2) 10.3 µg/g (Halifax Hbr., N.S.)(2) 13.0 µg/g (St. John's Hbr., Nfld.)(2)	0.75 µg/g (Ocean Dumping Control Act)
Biota	0.2 µg/g (marine fish) 0.5 µg/g (freshwater fish) 0.1 µg/g (clams, mussels, oysters)	0.06 — 4.9 µg/g (swordfish) 0.02 — 3.5 µg/g (eels, N.B. and N.S.) 0.77 µg/g (average — striped bass, Shubenacadie r.)(3) 2.13 µg/g (average — striped bass, St. John r.)(4) 0.64 — 2.62 µg/g (lake trout, Labrador)(5)	0.5 µg/g (National Health & Welfare guidelines for fish)

(1) Kozak, 1979[22].
(2) Worst Case Value.
(3) Ray *et al.*, 1984[150].
(4) Dadswell, 1975[151].
(5) Goff, 1980[152].
Source: Summarized in Wilson and Travers, 1977[148]; Sherbin, 1979[26]; CCREM, 1985[153], except where noted.

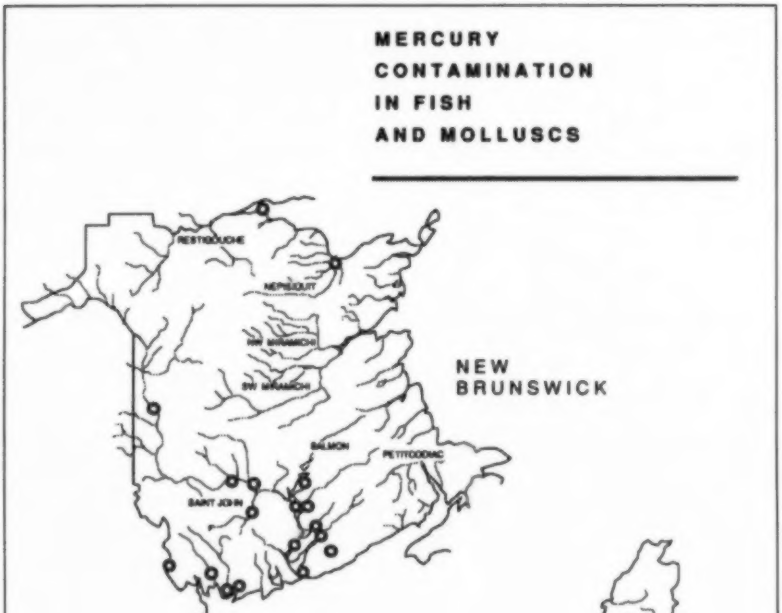

MERCURY CONTAMINATION IN FISH AND MOLLUSCS
RESTIGOUCHE
NEPISIGUIT
NW MIRAMICHI
SW MIRAMICHI
NEW BRUNSWICK
SALMON
PETITCODIAC
SAINT JOHN
NOVA SCOTIA
SALMON
PHILLIP
CORNWALLIS
SHUBENACADIE
ANNAPOLIS
LA HAVE
○ Concentration greater than 0.5 µg/g

Figure 22 Mercury contamination of fish and molluscs in New Brunswick and Nova Scotia[143]

Some microorganisms in aquatic bottom sediments are able to convert inorganic mercury to the highly toxic and bioavailable methyl mercury, which is accumulated in fish and humans[148].

Sources of mercury contamination in the Atlantic region include: geological release; long range atmospheric transportation and deposition; municipal sewage; paint application; fluorescent tube breakage and industrial point sources including chlor-alkali plants, smelters, fertilizer plants, pulp mills, coal mining and washing operations and coal-fired power stations[148]. In 1978, the chlor-alkali plants at Dalhousie, N.B., and Pt. Abercrombie, N.S., discharged the largest quantities of mercury in the region, although mercury emissions from the two plants have declined by 75% since then. Increased coal combustion for the generation of electricity has made thermal power plants the largest anthropogenic source of mercury emissions in the region (approximately 1,000 kg per year). (See section 1.2.1). Municipal sewage has been estimated to contribute 19% of all mercury loadings to coastal waters[149].

Background levels of mercury in sediments are generally below 0.1 µg/g in the Atlantic region (Table 18)[148]. Mercury in sediments adjacent to the Dalhousie chlor-alkali plant range from 0.1 µg/g to 8.1 µg/g[148], which is generally above the 0.75 µg/g Ocean Dumping Control Act limit. Mercury levels in sediments are also occasionally elevated at the mouths of rivers or at several harbours, including St. John's, Nfld., Eddy Point, N.S., and Halifax, N.S.

Other pockets of mercury contamination have been identified in the Atlantic region (Figure 22). The Saint John River Estuary, and the St. Croix, Shubenacadie and LaHave rivers have elevated mercury concentrations in the water column (Table 18)[148]. Fish from these and several other rivers exceed the 0.5 µg/g Health and Welfare Canada guideline for mercury. For example, average mercury concentrations (in muscle tissue) for older striped bass caught in the Annapolis River and younger striped bass caught from the Shubenacadie River were 0.77 µg/g and 0.51 µg/g, respectively[150]. Striped bass caught in the Saint John River averaged 2.13 µg/g[151], and concentrations in northern pike and lake trout from Lake Winokapau, Labrador, ranged between 0.64 and 2.62 µg/g[152]. With the exception of the Saint John River, these elevated mercury levels are likely to be the result of low-level geological release[152,150]. Acidic waters which are common in parts of Nova Scotia and New Brunswick can mobilize mercury from sediments, thereby increasing its availability and concentration in water[152].

Mercury levels in most swordfish caught off Nova Scotia exceed the 0.5 µg/g Health and Welfare Canada guideline. As a result, swordfish was banned from sale for human consumption in 1971, but upon re-evaluation in 1979, the ban was lifed. The latter action was based on the small average per capita consumption of the fish, which was determined to result in a reduced health risk.

Mercury, particularly the organic methyl mercury, is highly toxic to biological organisms. Reproduction of rainbow trout has been eliminated by exposure to 0.23 to 0.94 μg/L, methyl mercury. Spawning of fathead minnows and reproduction in the water flea, *Daphnia*, have been significantly impaired at methyl mercury concentrations below 0.1 μg/g[148]. The health of humans can be impaired by consistently eating more than 1 pound of fish containing 0.5 mg/kg methyl mercury per week. The ratio of methyl to total mercury is variable, but while inorganic mercury predominates in water, the highly toxic methyl mercury generally predominates in fish[148].

3.1.1.2 Cadmium

Cadmium is a soft, silvery white metal which occurs naturally in the earth's crust and can act as a cumulative and highly toxic poison[154]. Cadmium is used in the electroplating industry, and in the manufacture of long-life batteries, television picture tubes, super phosphate fertilizers, paint pigments, poly-vinyl plastics, ceramics and motor oil[154,155]. Sources of cadmium contamination in the Atlantic region include the Belledune lead smelter and fertilizer plant, the Surrette Battery plant near Springhill, N.S., base metal mines, electroplating operations and thermal power plants[108,154]. New effluent treatment systems at the Belledune lead smelter have reduced cadmium loadings by 97% since 1980[108]. The total generating capacity of thermal power plants is expected to increase in the region, leading to a potential increase in cadmium emissions.

Belledune Harbour in northern New Brunswick is extensively contaminated with cadmium (Table 19). The concentration of cadmium in Belledune Harbour averaged 25.5 μg/L in 1980, 5 times higher than the U.S. EPA standard for the protection of marine life[158], and almost 400 times the average for the Gulf of St. Lawrence[159]. Effluent controls commissioned in November, 1980 have, however, led to the reduction of cadmium in the harbour water.

Background levels of cadmium in soils in the Atlantic region range from 0.012 to 0.470 μg/g (Table 19). Background levels of cadmium are 1 to 2 μg/g[154] in freshwater sediments and below 0.5 μg/g in marine sediments[156]. Several harbours in the region have sediment values above the Ocean Dumping Control Act Limit of 0.6 mg/kg (Table 19). These include: Pt. Verte, N.B.; Dalhousie, N.B.; Bathurst, N.B.; Newcastle, N.B.; Halifax, N.S.; Canso, N.S.; Charlottetown, P.E.I.; St. John's, Nfld.; Corner Brook, Nfld. and Fermeuse, Nfld.[154,147].

TABLE 19
Cadmium in the Atlantic Provinces

Medium	Background Levels	Elevated Levels	Guidelines or Regulated Limits
Air	0.001 — 0.01 ng/m^3(1)	0.023 μgm^3 average (near Surrette Battery plant, N.S., 1973)(1)	50 μgm^3 (U.S. Guidelines for industrial workers)
Water	L1.0 μg/L (fresh)(1)	1 — 14 μg/L (Sydney Mines pond, N.S.)(1) 2 — 12 μg/L (Knights Brook, N.B.)(1) 20 μg/L (Sherbrooke, N.S. water supply, 1977)(1)	0.2 μg/L (DOE Protection of Aquatic Life) 5.0 μg/L (Cdn. Drinking Water Standard)
	L0.22 μg/L (marine)(3)	25.5 μg/L (Belledune Hbr., 1980)(2)	4.5 μg/L (U.S. EPA for marine life)
Soil	0.012 — 0.47 μg/g(1)	3.2 — 27.1 μg/g (L1 km Belledune lead smelter)	8 μg/g (5 rural) (excessive by Ont. MOE)
Sediments	1.0 — 2.0 μg/g (freshwater)(1) L0.5 (marine)(3)	0.9 — 32.0 μg/g (Salmon r., D Cape Breton, N.S.)(4) 13.7 μg/g (Pt. Verte, N.B.)(1) 4.2 μg/g (Newcastle, N.B.)(1) μg/g (St. John's, Nfld.)(1) 8.6 μg/g (Fermeuse, Nfld.)(1)	0.6 μg/g (ODCA)
Lobster	2.8 — 17.2 μg/g (wet wt.) (digestive gland)(2)	13.7 — 652.0 μg/g (digestive gland, Belledune, 1981)(2) 0.03 — 0.64 μg/g (muscle, Belledune, 1981)(2) 3.7 — 79.1 μg/g (digestive gland, Pictou Hbr.)(1) 7.2 — 53.4 μg/g (digestive gland, North Lake, P.E.I.)(1)	400 — 500 μgwk human consumption (FAO)

Source: (1) Baker and Matheson, 1980[154].
(2) Hildebrand, 1984[108].
(3) Swiss *et al.*, 1980[156].
(4) Westlake and Smith, 1983[157].

Cadmium acts as a cumulative poison due to its long persistence in the environment[160], although there is little evidence that cadmium is biomagnified in the food chain[161]. While cadmium is highly toxic to some plants, other edible plants can concentrate cadmium without obvious signs of damage, consequently posing a threat to human health[154]. Cadmium in the aquatic environment at concentrations less than 0.0005 mg/L can accumulate in tissues of seaweeds, crustaceans, polychaete worms and molluscs[162]. In general, cadmium is more bioavailable in freshwater, as it is strongly associated with chloride ions in saltwater[163].

Documented effects of cadmium on fish and aquatic invertebrates include gill damage, behavioral changes, altered respiratory rates, internal organ damage, reproductive impairment and direct mortality[154]. Concentrations of cadmium in the water column as low as 8-10 µg/L have been lethal to fish, while concentrations as low as 0.001 mg/kg in sediment have been observed to have chronic sub-lethal effects on the common brook trout[164]. In general, although pockets of contamination occur in the Atlantic region, ambient concentrations are of the magnitude where widespread lethal or sub-lethal effects are unlikely[165].

The major source of cadmium intake in human populations, excluding occupational exposures, is food and cigarette smoking. Foods containing the highest levels of cadmium are organ meat, such as liver and kidney, seafood (especially shellfish) and certain cereal grains such as rice. The average Canadian daily per capita intake of cadmium from food is 67 µg/day, which is comparable with the FAO guideline of 57-72 µg/day[165].

3.1.1.3 Lead

Lead is a soft, bluish grey metal which occurs naturally in the terrestrial and aquatic environment. Lead serves no beneficial biological functions and is one of the few metals considered to be a contaminant of the open ocean[136]. Excellent pliability and corrosion resistance have made lead one of the most useful non-ferrous materials available. Lead is used as a gasoline anti-knock additive, and is also used in water pipes, storage batteries, solder, bearings, pesticides, paints, glass, ceramics, enamel coatings, radiation shielding, printing type and in various alloys[166].

Automobiles emit the largest quantities of lead in the Atlantic region, approximately 6,000 tonnes per year. (See section 1.1.6). This is expected to decrease by 60% after the introduction of stricter standards for lead concentrations in gasoline in 1987. Other anthropogenic sources of lead in the region include: the lead smelter in Belledune, N.B.; the Surrette Battery plant near Springhill, N.S.; the Canadian National brass foundry in Moncton, N.B.; thermal power plants; urban runoff; sewage sludges, and dredging which increases the availability of lead which was previously immobilized in sediment[167,166,168]. Seepage from base metal mines is also a major source of lead, and concentrations above the 0.2 µg/L guideline under the Fisheries Act have been detected in several streams below base metal mines in northern New Brunswick[108].

Lead has been demonstrated to accumulate in most biota. Plants can absorb airborne lead deposited on leaves or can absorb lead from soils[167]. Vegetation 16 km from the smelter at Belledune had lead concentrations greater than the level considered to be excessive (100 mg/kg) by the Ontario Ministry of the Environment standards[108]. Aquatic microorganisms can also accumulate lead from water, and fish can absorb lead through their body surface or from the food they consume[167]. Benthic organisms, especially mussels, are strong accumulators of lead from water and sediment[167]. Lead can also accumulate in humans, in fact the average daily intake of lead from food in Canada is only 2-3 times below levels which would result in unacceptable lead accumulations[167].

Lead poisoning in humans can result in learning difficulties, fatigue, impaired reproduction, and in severe cases, brain damage and death[167]. Exposure to airborne lead from vehicle exhausts is an important health concern, although monitoring at 11 NAPS stations in the Atlantic region has shown a definite decline in annual average lead levels between 1974 and 1983. The ingestion of lead from paint chips and urban dusts has led to elevated blood-lead levels in children from both large and small cities[166,167]. Lead in street dusts has not been extensively monitored in this region, but due to the increased use of unleaded gasoline, concentrations in dusts have likely decreased.

3.1.1.4 Arsenic

Arsenic is a semi-metallic element which can be found at low levels in air, water, soil and living organisms. High natural levels occur near deposits of minerals such as gold, pyrite and slate. Activities such as gold mining, quarrying and construction have disturbed rock formations, thus increasing the availability of arsenic, resulting in elevated concentrations in soils and watercourses[169,81]. Plants from tailings areas at abandoned gold mines in Nova Scotia had arsenic concentrations at least one order of magnitude higher than similar plants collected away from tailings areas (up to 834 μg/g dry wt.)[169].

Other anthropogenic sources of arsenic contamination in the Atlantic region include the industrial smelting of zinc and lead ores, the combustion of fossil fuels, and the agricultural use of arsenical herbicides, pesticides and defoliants[170]. In 1982, the Belledune, N.B., lead smelter discharged 6 tonnes of arsenic into Belledune Harbour, considerably lower than the 27.3 tonnes discharged per year before 1980. Arsenic loadings from individual rivers entering the Baie des Chaleurs range from 0.74 tonnes to 6.5 tonnes per year[108], although much of this may originate from natural erosion of arsenic bearing soils and bedrock.

Arsenic contamination of groundwater is a major problem in Nova Scotia. The root of the problem lies with naturally high arsenic concentrations in underlying bedrock, particularly in Halifax and Guysborough counties. Wells having arsenic concentrations above the 0.05 mg/L Health and Welfare Canada guideline for drinking water quality have been discovered in the Waverley and Eastern Shore areas of Nova Scotia (Table 20). Arsenic contamination has often been inadvertently increased by using arsenic contaminated rock to line dug wells[81]. High arsenic concentrations have also been measured in sediments of 7 lakes in the Waverley area (up to 804 ppm As, dry wt.), making them highly questionable as alternative surface water supplies[81,172].

TABLE 20
Summary of Arsenic Concentrations in Well Samples in Nova Scotia (1976)

County	No. of Wells Sampled	Above Limit > 0.05 mg/L	Below Limit < 0.04 mg/L	At or Near Limit 0.04 & 0.05 mg/L
Halifax	449	65	341	43
Guysborough	52	3	46	3
Lunenburg	12	0	12	0
Hants	18	0	16	2
Queens	7	0	7	0
TOTALS	538	68	422	48

Source: Grantham, 1976[171].

The average daily intake of arsenic by Canadians is approximately 0.03 mg from food, while the equivalent intake from contaminated Nova Scotia well water is between 0.12 and 0.45 mg. This has resulted in some cases of chronic arsenic poisoning[170]. Increased incidence of cancer has been related to chronic consumption of water with arsenic concentrations greater than 0.30 mg/L in Taiwan and Chile, although no data exists to demonstrate this link in Canada[170].

3.1.2 Other Contaminants

3.1.2.1 Polychlorinated Biphenyls (PCBs)

Polychlorinated biphenyls (PCBs) are man-made liquids which are highly stable, non-corroding and resistant to both heat and biological degradation[173]. These and other characteristics such as excellent insulating and thermal properties contributed to their widespread use after they were first manufactured on a commercial scale in 1929[174]. PCBs have been used in electrical transformers, capacitors, hydraulic fluids, heat transfer fluids, paints, adhesives, cutting oils, lubricants, inks, flame retardants, water proofing agents and carbonless reproduction papers[174].

PCBs are of environmental concern because of their wide dispersal, persistence, chronic toxicity, bioaccumulative capacity and biomagnification along the food chain. Human exposure to PCBs has been associated with skin disorders, liver function abnormalities, growth depression in children and respiratory impairment[175].

PCBs ceased to be used in industrial processes in Canada in 1978 and are now banned from all new uses[147]. New electrical equipment containing PCBs has been prohibited since July 1, 1980, although transformers or capacitors in service before that date may still contain PCBs. Table 21 illustrates that 83% of the 812,000 litres of PCBs inventoried in the Atlantic region is contained in transformers, while the remainder is in capacitors or in storage[176]. Many of the transformers in use in the Atlantic region were manufactured in the late 1960s, therefore, since the average life of a transformer is 35-40 years, PCBs will continue to be in use to the year 2005[177]. (See also section 3.3.1).

Only 60% of the PCBs known to have been imported into the region are accounted for in the inventory. Most of the remainder is assumed to have been dispersed or re-distributed into the environment from municipal sewage treatment plants, industrial plants, landfill sites, incinerators, and fish processing plants. Some PCBs have been sent out of the region for destruction. PCBs can also be transported in the atmosphere and be redeposited elsewhere, or be released through accidental leaks or spills from electrical equipment[174,178]. An average of 17 spills were reported to EPS in the Atlantic region between 1981 and 1984. Most spills had volumes less than 5 L, although larger incidents included 810 litres spilled from a damaged transformer into the Exploits River, Nfld., during a flood (1 other transformer and 43 capacitors were recovered after the water receded), and 2,273 litres of PCB-contaminated transformer oil leaked from 60 dismantled transformers in New Brunswick in 1984[179,180].

Background levels of PCBs in the marine environment are approximately 5-20 ng/g in sediments, 1 to 100 ng/L in surface waters and from 0.01 to 5.0 µg/g wet wt. in finfish[130]. (See section 2.3.2). PCBs can slowly accumulate in fish, therefore tissue concentrations in large, older fish may exceed the 2 ng/g Health and Welfare Canada guideline. PCB levels in eastern Canadian fish are higher than those found in the Arctic, but lower than those found in fish from the North Sea[130]. Elevated levels of PCBs were found in striped bass in the Saint John and Annapolis rivers and in trout from the Exploits River. This may be the result of the prevalence of older fish which slowly accumulated PCBs[150] in the first two rivers and the large PCB spill in the Exploits River[181].

TABLE 21
Volume of PCBs in the Atlantic Region, 1985 (litres)

Province	Volume in Transformers	Volume in Capacitors	Volume in Storage	Total
Nova Scotia	253,031	17,244	20,020	290,295
New Brunswick	227,249	45,514	14,916	287,679
Prince Edward Island	9,956	206	517	10,679
Newfoundland	186,774	7,230	29,363	223,367
Atlantic Region	677,010	70,194	64,816	812,020

Source: EPS, 1985(a)[176].

PCBs are distributed in the environment throughout the Atlantic region, but more serious contamination is restricted to several specific locations throughout the region. PCB levels of 52,200 ng/g were found in sediments sampled in Muggah Creek near the Sydney coke ovens. This decreased to 20 ng/g at the mouth of Muggah Creek in Sydney Harbour[182]. PCB concentrations ranging from non-detectable to 6,750 μg/g were found in sediments of the Exploits River following the large spill, but much of the contaminated material was removed from the river[181]. PCB contaminated sediments have also been sampled at Fortune, Nfld. (216-21,600 ng/g); Canso, N.S. (1-27,000); Halifax, N.S. (17-22,000); Petit-de-Grat, N.S. (24-20,000), and Charlottetown, P.E.I. (0.5-300)[147]. The elevated concentrations of PCBs in sediments at Petit-de-Grat, and other small harbours in Nova Scotia, may have resulted from fish offal being discharged into the harbour from local fish processing plants. Process wastewater carried PCBs from fish tissue into the harbour[93].

3.1.2.2 Dioxins

Chlorinated dibenzodioxins (dioxins) are a highly toxic group of chemicals which are by-products formed during the production or combustion of other organic chemicals or materials. The main anthropogenic sources of dioxin include the use of the phenoxy herbicides 2,4-D and 2,4,5-T, the production and use of pentachlorophenol (PCP) as a wood preservative, and the incineration of municipal garbage. Other potential combustion sources include forest fires and cigarette smoking[183].

In the Atlantic region, wood preserving plants at Truro, N.S., Newcastle, N.B., and Clarenville, Nfld., use the dioxin-containing PCP to protect wood against insect attack and decay. Effluent from the first two plants has resulted in some dioxin buildup in the underlying sediments of adjacent streams, but this is not expected to result in any adverse impacts. Soil contamination where treated wood is stored, or at the base of PCP treated utility poles is also of concern[184]. In addition, dioxins have been found in the livers of chickens housed on PCP contaminated wood shavings[183]. (See section 3.2.1.2).

Elevated levels of the highly toxic 2,3,7,8-TCDD were detected in the herbicide 2,4,5-T used in the region during the early 1970s. Prior to this, a mixture of 2,4,5-T and 2,4-D used by the U.S. armed forces may have contained up to 100 μg/g of TCDD[185]. TCDD content of 2,4,5-T is presently regulated at 0.1 μg/g under the federal Pest Control Products Act, although the New Brunswick Department of the Environment refused treatment of an area with 2,4,5-T because TCDD levels were higher than their more stringent 0.01 μg/g provincial limit.

Although dioxins in the environment are generally several orders of magnitudes below lethal levels, examples of acute mortality are documented outside of the Atlantic region. Seventy chickens died within weeks of spraying a road with dioxin contaminated waste oil[186] and large numbers of fish and domestic animals died in Vietnam following the spraying of "Agent Orange", a mixture of 2,4-D and 2,4,5-T highly contaminated with dioxins[187]. Some dioxins, such as the highly toxic 2,3,7,8-TCDD (found in 2,4,5-T but not in PCP), are relatively persistent and can accumulate in organisms, although biomagnification along the food chain is unlikely[183,188]. Dioxins have been detected in fish and gull eggs in the Great Lakes, and at levels an order of a magnitude lower in herring gull eggs in the Bay of Fundy[189].

There is, however, no evidence of recurring problems from the low environmental levels of dioxins encountered at present in the Canadian environment[183].

Continuous or intermittent low level exposure to dioxins is the major human health concern. Chloracne (a boil-like acne) and neurological disorders have been identified in workers exposed to dioxins in industrial accidents, but the relationship between dioxins and reproductive failure, birth defects, and cancer is uncertain[183]. Under the Food and Drug Act, no food may be sold if contaminated with detectable levels of dioxins. Fish is the exception, and the acceptable level is 20 ppt. TCDD, at a consumption rate of 113 g (.25 lb.) per week[183]. Many Atlantic Canadians consume larger quantities of fish, but fish caught in the region contain substantially less dioxins than those caught in the Great Lakes, upon which the standard is based.

3.1.2.3 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons (PAHs) are among the oldest known carcinogens in humans, having been identified as the active ingredient associated with soot which caused tumours in chimney sweeps during the 18th Century[190]. PAHs are found in small but detectable concentrations in water, air, soil and sediments. The main route to the environment is via atmospheric emissions and subsequent fallout, although surface runoff and industrial effluents are also important. The principal anthropogenic sources of PAH include: thermal power plants; vehicle exhausts; coke ovens; creosoted wharf pilings; incinerators; oil refineries; wood burning appliances; sewage and oil spills[191]. The conversion of power plants from oil to coal, the increased level of residential fuel-wood burning and potential increases in coke production threaten to increase PAH emissions in the Atlantic region[8].

TABLE 22
Polycyclic Aromatic Hydrocarbons (PAHs) in the Atlantic Region

Medium	Background Levels	Elevated Levels	Guidelines or Regulated Limits
Air	0.38 ng/m³ (national U.S. average BaP)(2) 0.10 ng/m³ (U.S. average rural — BaP)(2)	36.56 ng/m³ (Sydney, N.S.) 3.74 ng/m³ BaP (Sydney)(2) 0.34 ng/m³ BaP (1.66 ng/m³ worst case) (Lower Sackville, N.S.)	No guidelines for ambient levels
Water	L1.0 ng/L (total PAH)(6)	6.9 ng/L BaP (Lingan mine outfall on shoreline)(4)	10 ng/L total PAH (International Joint Commission (IJC) Guideline to protect aquatic life)
		5.7 ng/L BaP (Runoff from coke oven dumps, Sydney)(4)	2.8 ng/L total PAH (U.S. EPA criteria for human health)
Sediments	10-20 ng/g PAH(2)	21,110 ng/g (4 PAH adjacent to creosoted wharf timbers)(5) 110,000 ng/g BaP; 2,800,000 ng/g PAH (Muggah Creek)(4) 150-10,000 ng/g PAH (Sydney Harbour)(4)	1000 ng/g (IJC Guideline to protect aquatic life)
Biota			
Lobster	L5 ng/g BaP (digestive gland)(1) L10 ng/g BaP (marine biota)(4)	387-2240 ng/g (wet wt.) BaP (digestive gland) (South Arm, Sydney Harbour)(1) 8-43 ng/g (wet wt.) BaP (tail muscle) (South Arm, Sydney Habour)(1) 545 ng/g BaP (digestive gland) (creosoted lobster pounds — Atlantic region)(3)	1000 ng/g BaP (IJC Guideline to protect upper levels of food chain)
Mussels	5 ng/g BaP(1)	221 ng/g BaP (Sydney Harbour)(1) 4,100 ng/g total PAH (Sydney Hbr.)(1)	1 ng/g BaP (recommendation for foodstuffs in Canada)(7)

BaP — Benzo(a)pyrene

Source:
(1) Sirota et al., 1984[105].
(2) Atwell et al., 1983[8].
(3) Uthe et al., 1984[193].
(4) Matheson et al., 1983[104].
(5) Eaton and Zitko, 1978[192].
(6) Clark and McLeod, 1977[194].
(7) Uthe, 1979[195].

Prior to 1980, regional monitoring centred upon the release of PAH from creosoted wood products. Investigations determined that PAH concentrations in marine sediments and shellfish immediately adjacent to creosoted wharf structures were considerably higher than background levels[192] (Table 22). Monitoring has continued on PAH uptake from creosoted structures, but has also recently focussed on PAH discharges from the steel plant and coke ovens at Sydney, N.S., where approximately 3.5 million kg of PAH are estimated to be contained in sediments in Muggah Creek. Sediment PAH values in the South Arm of Sydney Harbour are 20 times the highest values recorded for Boston Harbour and PAH in lobsters is 26 times the background levels for Atlantic coastal lobsters[104]. Engineering feasibility studies for possible clean-up methods for the site were in progress in 1985. (See section 2.2.1.6.).

Elevated levels of PAH have also been detected in air and water samples from industrial sources in Cape Breton. Particulate PAH concentrations at two sites downwind of the Sydney coke ovens averaged 31.16 and 36.56 ng/m^3, as compared to 3.48 ng/m^3 at an upwind control site. These values are higher than PAH concentrations sampled at larger cities in Ontario[196]. (See section 1.1.1.1). Runoff from the coke oven dumps at Sydney contained up to 5.7 ng/L of benzo[a]pyrene, an extremely toxic PAH (Table 22)[104].

The uptake of PAHs has been demonstrated in microorganisms, plants, invertebrates and vertebrates. Metabolism of PAH is fairly rapid, therefore, biomagnification up the food chain is unlikely[191]. Since ambient PAH levels are generally low in the Atlantic region, no acute toxicity problems of a widespread nature should be encountered. The primary concern is chronic mutagenic and carcinogenic effects[104], but there is virtually no published literature on possible health effects of ambient levels of PAH on the general public[8].

3.2 Pesticides

Toxic chemicals are usually thought of as harmful substances and wastes which accidentally escape into the environment. Chemical pesticides include insecticides, fungicides and herbicides, which are consciously released into the environment to control plant and animal pests. The old rule of thumb, that if pesticides are used according to the directions on their label there will be no harm, is not always tenable. For example, the early organic, artifically synthesized pesticides were properly used in this narrow sense, yet subsequent research has demonstrated their significant, long term effects on the health of ecosystems. Although many early pesticides, including DDT and dieldrin, have now been banned from use, the number of different chemicals used as pesticides has steadily grown. For example, as of January 1 1985, 514 chemicals were registered for use in Canada as compared to 30 in 1940 and approximately 400 in 1979[197,198].

Pesticides enter the terrestrial and aquatic environments by direct application, mobilization in intermittent stream channels, surface runoff, leaching, drift from nearby spray areas, wind erosion and precipitation[199]. Direct application is an important short-term route of entry and may result in acute toxic effects on non-target organisms. Overland flow and intermittent streams are important modes of entry to non-target areas, especially after precipitation events[200]. Aerial, and to a lesser degree ground spraying, can result in significant deposition of pesticides outside of target areas[201], although drift may be mitigated through the use of a buffer zone at the edge of the spray block[202].

3.2.1 Forestry Herbicides

The use of herbicides in the forest industry has received considerable public attention in the Atlantic region. The "herbicide trial" in Nova Scotia in 1983 highlighted the apparent conflicts within the scientific community regarding the effects of herbicides on human health. (See section 5.2). The implications of herbicide spraying on the environment are, however, well documented, although most data is generated from outside of the region.

3.2.1.1 Herbicides Used in the Region

The phenoxy herbicides 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and 2,4-dichlorophenoxyacetic acid (2,4-D) are the herbicides which have been most widely applied in forestry operations in the Atlantic region during the past 5 years. The recently approved glyphosate has also begun to be widely used. The prime use of these herbicides is to stimulate the growth of conifers in the forest industry by controlling deciduous trees and broadleaf weeds. They are also used to control brush on crops, rangeland, rights-of-way, industrial property and lawns. Phenoxy herbicides are used because they are harmless to most conifers, but at the same time are highly toxic to unwanted shrubs and deciduous trees such as maple and birch[201].

Approximately 85,000 kg of herbicides were applied to over 28,000 ha. in New Brunswick (0.4% of New Brunswick's forested area) in 1984, representing 85% of the Atlantic region's total use. The use of 2,4-D has declined in recent years, and the world's major manufacturer of 2,4,5-T has recently announced that it has abandoned its production due to public controversy surrounding the chemical. Therefore, in the Atlantic region, glyphosate is replacing 2,4-D and 2,4,5-T as the preferred forestry herbicide[203]. There have been few regional studies conducted to determine the environmental effects of glyphosate, although a study was underway in 1985 to determine the fate and terrestrial effects of glyphosate use[203]. In addition, an environmental assessment was underway in Newfoundland in 1985 by the provincial government and the pulp and paper industry, to determine potential environmental impacts before the initiation of an operational glyphosate spray program. Because 2,4-D and 2,4,5-T have been the most extensively used forestry herbicides in the region over the past 5 years, the fate and effects of these chemicals will be further outlined below.

3.2.1.2 Environmental Impacts

Residues of 2,4-D or 2,4,5-T in surface water courses tend to drop below non-detectable levels within several days or months of application. Water characteristics such as flow rates, temperature, oxygen concentration and microorganisms affect the rate of herbicide loss from water[204]. A survey of a pond in northern New Brunswick indicated that 2,4,5-T residues persisted in water and bottom sediments for 96 hrs., although further sampling was required to determine the full length of time that detectable levels would have been encountered[205]. In addition, no dioxins (a contaminant of 2,4,5-T) were found in sediment or water samples, although dibenzofurans were found in moss. The source of the dibenzofurans was unknown, but was not the result of applications of 2,4,5-T[205].

Water quality characteristics are also known to modify the toxic potential of phenoxy herbicides. For example, regional studies have demonstrated 2,4-D to be 20 times more toxic to rainbow trout at pH 4.5 than at pH 7.0. These results are important because acidified waters in southwestern Nova Scotia have been recorded at pH below 5.0[200].

Atlantic salmon and several species of trout are highly sensitive to the acute toxic effects of phenoxy herbicides, particularly during the early life stages[206]. These species, when exposed to 2,4-D at levels of 2 mg/L and higher, have shown a variety of sublethal effects, including behavioural changes[207]. Both 2,4,5-T and 2,4-D are not accumulated in higher levels of the food chain but can be concentrated by phytoplankton. Fish do not appear to accumulate substantial residues of phenoxy herbicides[199].

Research indicates that there are few toxic effects on vertebrates exposed to phenoxy herbicide spray or residue. Harmful effects in laboratories have come from large doses of herbicides that would not normally be found in the field[199]. Shifts in vegetation type due to herbicide use have affected bird and mammal populations due to alteration in cover, exposure to predation or the reduced number of suitable sites for den or nest building[199]. Only one study of this kind has been conducted in the Atlantic region. Preliminary results after spraying sample plots in central Nova Scotia with 2,4,5-T indicated no short term changes in the species abundance or density of birds and small mammals[208].

3.2.2 Forestry Insecticides

Fenitrothion and aminocarb are the two principal chemical insecticides which are being applied for the control of the spruce budworm in the Atlantic region. In addition, fenitrothion is also used in Newfoundland to control the hemlock looper. Of the two, fenitrothion has been used more extensively for a longer period of time, having been introduced in the late 1960s as a replacement for DDT (Figure 23). In 1984, 284,189 kg (of active ingredient) of chemical insecticides were sprayed over 1,147,000 ha in the Atlantic region[209]. More than 95% of this total was sprayed over New Brunswick, although insecticide use in New Brunswick has been decreasing over the past 4 years (Figure 23).

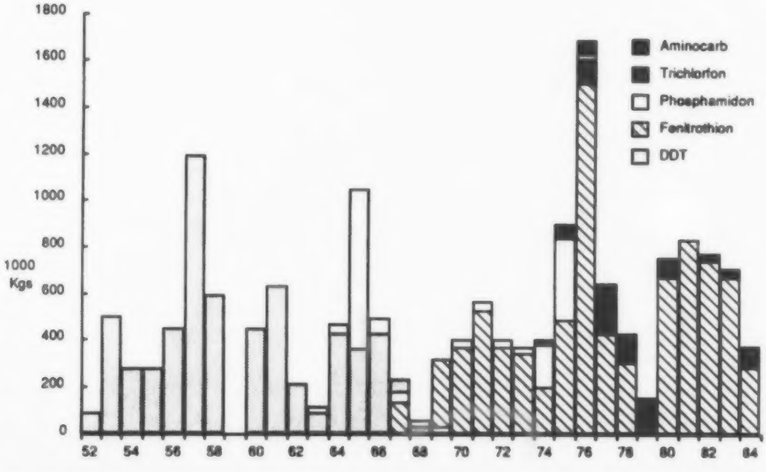


Figure 23 Chemical insecticides used in New Brunswick's operational spray program (1952-1984)[209]

3.2.2.1 Fate and Persistence

Environmental monitoring conducted in the Atlantic region has shown that fenitrothion and aminocarb are rather short-lived in the environment and that residues in most environmental samples decrease rapidly with time[210,211].

The major routes for fenitrothion removal from fresh water are evaporation, sedimentation, breakdown by sunlight and microbial activity[200]. Several species of mussels and clams may concentrate fenitrothion above ambient levels, but fairly rapid excretion reduces transmission to higher levels of the food web[212]. In spite of the fact that fenitrothion is not normally persistent, low level fenitrothion contamination has been demonstrated away from spray areas in New Brunswick. Shellfish collected from locations 50 km distant from spray blocks had low, but detectable, fenitrothion concentrations[213].

The half life of aminocarb ranges from 1 week[214] to 2½ weeks[215] because of decomposition by light and microorganisms. Aminocarb residues have not been detected in sediments[216,217] or in a number of fish species after operational sprays in eastern Quebec and the Atlantic region[218], although residues persisted for 21 days in forest litter after a second operational spray near Bathurst, New Brunswick[219]. This latter research suggests that aminocarb residues may be available to biota for longer periods than originally expected, although the consequences of this have not, as yet, been determined.

3.2.2.2 Environmental Effects

Fenitrothion may be impacting more than 100 species of native bees in New Brunswick[220], as well as predaceous invertebrates such as spiders and mites[221]. Predaceous invertebrates are important because several species are natural predators of the spruce budworm. Aminocarb has caused some mortality of spiders, wasps and beetles, but most species returned to normal population densities within one year[222].

Studies by the Canadian Wildlife Service in the Atlantic region indicate that fenitrothion may reduce breeding success and nestling growth rates in birds. White-throated sparrow nestling growth rates were reduced in areas sprayed with fenitrothion, and simulated overswathing (resulting in twice the normal dose) caused significant mortality and reduced breeding success[223]. Aminocarb is considerably less toxic to birds. No changes in bird breeding patterns, or in numbers and weights of fledgling songbirds have been observed due to aminocarb use[224,225].

Fenitrothion concentrations in lakes and streams after operational sprays are generally greater than levels found to be toxic to aquatic insects[226,227]. Short-term reductions in aquatic insect populations have been noted after the application of fenitrothion at operational dosages, although long-term population effects are generally not considered serious[228]. The effects of aminocarb on aquatic insects are highly variable and depend upon stream characteristics and application variations[200]. Little mortality however, has been observed in target areas treated with a newer aminocarb formulation[229].

With the exception of one isolated incident in central Quebec where 30 brook trout were found dead with high levels of fenitrothion residues[230], fish kills due to operational fenitrothion sprays have not been documented[231]. Concentrations of fenitrothion measured in natural water systems are usually below levels lethal to fish[200]. The results of environmental monitoring have been in general agreement that concentrations of aminocarb observed in aquatic systems after operational sprays are approximately 2 orders of magnitude lower than those required to produce toxic effects in aquatic organisms[226,232]. In addition, few environmental impacts were observed after aminocarb applications of twice the normal dose in a test stream at a plantation in northern New Brunswick[233]. Unfortunately, there have been no longer term investigations on the effects of fenitrothion and aminocarb on fish[231].

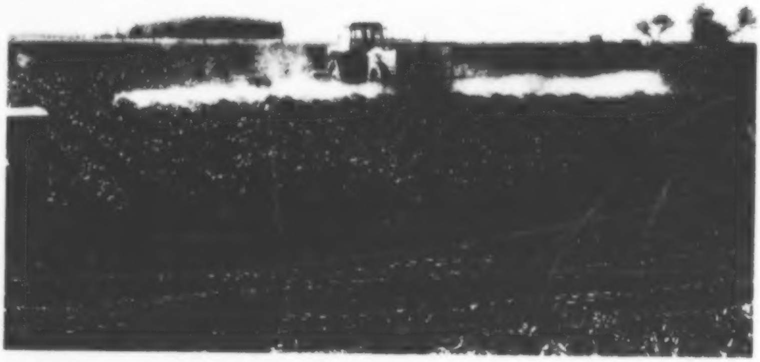
Although aminocarb is highly toxic to spiders, wasps and beetles, it is less toxic than fenitrothion to birds, fish, aquatic invertebrates and pollinators. In addition, the new Matacil 1.8 F formulation of aminocarb has been proven to be significantly less toxic to biota than previous aminocarb sprays[234]. Aminocarb is generally less persistent than fenitrothion, and is readily broken down by light and biological activity. Therefore, from an environmental perspective, aminocarb is the preferred chemical insecticide for the control of the spruce budworm in the Atlantic region although other methods such as biological controls (e.g., *Bacillus thuringiensis* (B.t.)) and alternative forestry practices should also be considered. (See also section 4.1).

3.2.3 Agricultural Pesticides

Agricultural pesticides enhance crop production by combating pests such as insects, weeds and fungi. In spite of the heavy use of pesticides in North America, 36% of agricultural crops are annually lost to pests in the United States[235], and a similar percentage are likely lost in Canada. If pesticides were no longer used, damage would range from insignificant losses in some crops to the total loss of other crops, although losses could be significantly reduced through the adoption of alternative agricultural practices (see below).

Approximately 220,000 kg of agricultural pesticides were sold in New Brunswick in 1983[236], and a survey of retailers indicated that 149,000 kg were sold in Prince Edward Island in 1982[237]. Similar data are unavailable for Newfoundland and Nova Scotia. Fungicides such as mancozeb, captan, and chorothalonil represent the largest quantities sold in Prince Edward Island and New Brunswick, followed by the herbicides dinoseb and diquat, and the insecticides phorate, disulfoton, carbofuran, and aldicarb[236,237].

In the Atlantic region, potatoes receive the largest amounts of pesticides, followed by tobacco, fruits and vegetables, corn and grain[237]. Pesticides applied to potatoes include insecticides for the control of 4 major insect pests (Colorado potato beetle, potato fleabeetle, potato leaf hopper, aphid), herbicides to control weed competition, and up to 10 applications of fungicides to prevent early and late blight[238]. In comparison, grain crops usually only receive early applications of insecticides and fungicides to protect seedlings[239].



The fate, persistence and environmental effects of agricultural pesticides are being monitored.

Agricultural lands in Canada currently receive 15 times more insecticide than forests[198]. The heavy use of insecticides has resulted in the major global problem of pests developing a resistance to the pesticides used. The number of insects and other arthropods that are resistant to insecticides has grown from 224 in 1970 to 428 in 1980[240]. Thirty-five plant diseases are now also resistant to pesticide treatment[198]. In numerous instances, pests resistant to one pesticide seem to quickly develop resistance to others. For example, houseflies resistant to several insecticides were effectively controlled by a new synthetic pyrethroid insecticide in 1978, but this same insecticide was ineffective in 1979[239].

One possible method to alleviate the resistance problem, and a more environmentally sound agricultural practice, is the concept of integrated pest management (IPM). IPM reduces pest damage to tolerable levels through a variety of techniques, including the introduction of genetically resistant crops, the release of natural predators and parasites, the release of sterile pests and the modification of agricultural practices to include techniques such as crop rotation and intercropping. IPM may still require pesticides, but often in smaller quantities, applied less frequently, on critical occasions[198].

Early investigations into aspects of IPM in Canada were begun in the Annapolis Valley of Nova Scotia during the 1950s, when it was observed that insecticides used in apple orchards killed many beneficial insects. Spraying resulted in species of mites, formerly kept at low levels by predators and parasites, emerging as major pests. Careful selection of pesticides and less frequent use allowed these beneficial insects to re-establish populations and reduced mite infestations. This success encouraged similar efforts in the rest of Canada[239].

3.2.3.1 Agricultural Pesticide Monitoring

Past environmental monitoring for pesticides in the Atlantic region has focussed on forestry insecticides, and to a lesser degree, on forestry herbicides. The fate, persistence and environmental effects of agricultural pesticides has become a recent focus of monitoring efforts, although few regional studies have yet been completed.

EPS has completed a study comparing fungicide drift from aerial and ground application in Prince Edward Island. This is important because drift can result in the deposition of fungicides in non-target areas. Some off-target drift was detected, but only 1.9% of the measured dose in the target area was detected 50 m downwind after aerial application, and less than 1.3% was measured 2 m from the edge of the spray block after ground application. Turbulence and higher release heights likely accounted for the larger aerial drift[241].

Measurable quantities of the insecticide aldicarb (trade name Temik) have been found in groundwater near potato growing areas in Prince Edward Island and New Brunswick. Concentrations of aldicarb in Prince Edward Island groundwaters average between 1.3 and 2.2 ppb, which is below the 10 ppb United States Environmental Protection Agency water quality standard[242]. Concentrations of aldicarb in a well near Woodstock, N.B., have been recorded as high as 30 ppb, but other wells were below the U.S. standard[243]. In this case, there may be reason for some concern, as aldicarb is highly toxic to mammals, birds and bees[244]. (See also the section on groundwater in Chapter 2).

Residues of the insecticide fenvalerate, a synthetic derivative of pyrethrin, have been detected in Prince County, Prince Edward Island. Residues ranged up to 300 ppb in soils and 1.6 ppb in stream sediments. No residues were detected in groundwater, surface water and shellfish meats[245]. Pyrethrins are powerful contact insecticides and are highly toxic to aquatic organisms, but they are relatively non-toxic to warm-blooded animals[244]. Ethylene thiourea (ETU), a breakdown product of the fungicide maneb, has also been found in the 10-15 ppb range in soils, although it was not detected in aquatic sediments, oysters, mussels and trout[246]. ETU has also been discovered in wells in Carleton County, N.B., but always below the 100 ppb Health and Welfare guideline[243].

3.2.3.2 Pesticide Contamination and Fish Kills

Fish kills occur when high concentrations of chemicals enter a water body in a short period of time from a chemical spill, or from runoff entering a stream following pesticide applications[238]. Many fish kills are caused by washing or loading spray equipment at streamside, or carelessly storing chemicals where they could accidentally be spilled into a water body[247]. These types of incidents caused several hundred fish kills in the Atlantic region in the late 1960s, until each Atlantic province eventually passed regulations (in P.E.I., Nfld., and N.B., mixing pesticides within a specified distance of water bodies is prohibited) or guidelines (N.S.), dealing with the use or misuse of spray equipment. Evidence indicates that the number of fish kills has subsequently been reduced, especially in P.E.I., where prior to the introduction of the Agricultural Chemicals Act in 1971, fish kills were a severe problem[248].

Fish kills due to pesticide misuse can still occur. For example, in 1982, several hundred fish were killed in Chute Brook, King's County, Nova Scotia, after the insecticide Guthion was spilled while loading spray equipment. Guthion powder residues were also found on the ground adjacent to the stream[249]. Two weeks later, a fish kill was reported in a tributary of the Cornwallis River, King's County, Nova Scotia. In this case the fungicide captan was spilled when spraying equipment was overfilled adjacent to a brook[249].

Fish are not the only biological organisms which can be affected by pesticide spills. In June 1983, 1 litre of the agricultural herbicide premerge was spilled in a brook near Centreville, N.B., causing a dairy farmer downstream to dump milk, due to potential short-term contamination of his cows' drinking water. In the spring of 1984, 5 wild geese died within minutes of drinking contaminated water from a puddle of standing water near a potato field at Vernon Bridge, Prince Edward Island. Later analysis confirmed that the water had high concentrations (208 ppm) of the toxic insecticide phorate, and that phorate was also present in tissue samples.

Phorate is not normally persistent, particularly when dissolved in water[249], but dry undissolved granules from an application in 1981 had apparently been transported by surface runoff to the puddle where the geese had died[250].

Groundwater supplies can also be affected by pesticide spills. (See also the section on groundwater in Chapter 2). For example, 40 residents were forced to find alternative water supplies after 136 containers of the agricultural herbicide Sinox PE (active ingredient — dinoseb) exploded and burned in a warehouse at the Kensington Industrial Park, Prince Edward Island. Traces of the herbicide were found in 16 wells and highly contaminated material at the site was sent to Quebec for incineration[251].

3.3 Hazardous Wastes

The management and disposal of hazardous wastes is a priority concern in Canada. In the Atlantic region, media coverage of PCB contamination at an Amherst, N.S., landfill and of discarded herbicide barrels at abandoned dumpsites in New Brunswick has focussed public attention on this issue. In spite of this media attention, a great deal of uncertainty still surrounds the issue of hazardous waste disposal.

Hazardous wastes include discarded or used products such as solvents or batteries, and by-products of the industrial processes which generate the products available to consumers. A working group made up of representatives from the federal government, provincial government and industry has developed technical criteria for designating hazardous wastes. To be defined as hazardous, wastes must either be flammable, corrosive, reactive, toxic (acute or chronic), radioactive, infectious, persistent, bioaccumulative or oxidizing.

3.3.1 Sources of Hazardous Wastes

An estimated 131,700 tonnes of hazardous wastes are generated annually in the Atlantic region. This represents 5% of the Canadian total[177,252]. Large industries such as petroleum refineries, pulp and paper mills, and chemical plants generate 90% of the total[177]. Smaller generators of hazardous wastes include community businesses such as dry cleaners, furniture finishers or photography studios, and institutions such as hospital or university laboratories. Electric power generation facilities are also a source of hazardous wastes such as PCBs. The average citizen also generates small quantities of hazardous wastes such as solvents, cleaning fluids, insecticides, herbicides or home and vehicle maintenance chemicals. (Thus even the private citizen can contribute to the problem of hazardous waste management).

Approximately 93% of hazardous wastes in the Atlantic Provinces are generated in New Brunswick and Nova Scotia[177]. Newfoundland generates about 6%[253], and P.E.I. less than 1%. Oily wastes account for approximately one-half of the wastes generated, followed by acid solutions, alkalis and solvents[177].

3.3.2 Disposal Methods

A survey of 110 industries in the Maritime Provinces revealed that the use of municipal dumps, on-site dumps, waste treatment and on-site storage were the preferred or only available waste disposal methods (Table 23). Several industries used a combination of methods[177]. In Newfoundland, 36% of hazardous wastes are disposed of in poorly operated on-site landfills[253]. A similar amount is disposed of in municipal dumps, while the remainder is disposed of in sewers, by burning, or is stored on-site. A significant quantity of waste or used oil is used as a dust suppressant on roads throughout the region[253]. This oil may contain contaminants such as lead, PAH and PCBs.

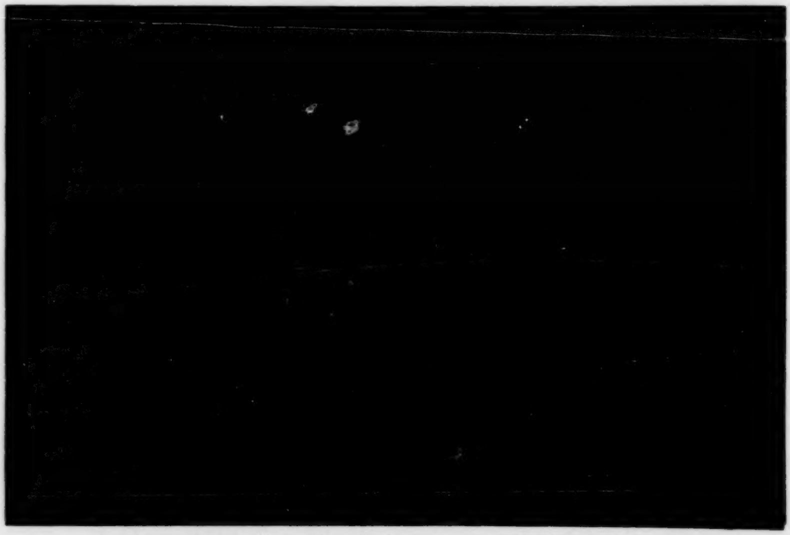
There are many alternative methods available to properly dispose of hazardous wastes. These include physical treatment (which includes filtering and precipitation), chemical treatment (which incorporates oxidation and neutralization), recycling, and the use of landfarms, high temperature incinerators, secure landfills and waste exchanges. Many industries, such as the wood preservation industry, send their hazardous wastes to central Canada for treatment or incineration[254]. Landfarms, whereby natural decomposition is allowed to take place, are used by refineries to dispose of 6,000 to 10,000 tonnes of oily wastes annually[255]. Although only 5% of liquid industrial wastes are recycled in the region (compared to 18% in Ontario), another 15% of the total amount of hazardous wastes generated in the region could be recycled[177,256]. (See section 4.3). In addition, approximately 500 tonnes per year are transferred in two waste exchanges, in which residues from one industrial process are used as raw material for a different process.

There is as yet no systematic or comprehensive approach to the problem of hazardous waste management in the Atlantic region[147]. Disposal is handled on a case-by-case basis, often employing undesirable practices. Acceptable disposal methods are used for only 19% of the hazardous wastes generated in Newfoundland and 38% of those generated in the Maritimes[177]. An additional 45% of the hazardous waste stream could be safely disposed of by using alternative practices. For example, better housekeeping practices and dewatering of sludges could effectively reduce the volumes of wastes requiring disposal. Alkaline sludges produced in the industrial gases industry (in the production of acetylene) could be used to neutralize acidic wastes from coal mine drainage and smelters. This alone could reduce the volume of hazardous wastes requiring disposal by 13-15 million litres[257].

TABLE 23
Hazardous Waste Disposal Methods
(110 Industries Surveyed)

Method	Frequency of Use*	Percentage*
Municipal dumps	67	60.9
On-site dump or treatment	40	36.4
On-site storage	20	18.2
Sewers	7	6.4
Private dumps	6	5.5
Shipment to central Canada	5	4.5

*Several industries used more than one method.
Source: EPS, 1980[177].



Inadequate waste disposal methods are common in the Atlantic region.

Even if acceptable disposal options were fully used, approximately 10,800 tonnes of wastes would require treatment at a facility combining incineration, physical/chemical treatment and secure landfilling. These generally toxic and persistent wastes include PCB, pesticides, paint sludges, tetraethyl lead sludge, latex wastes and heavy metal sludges.

Although special wastes such as PCBs have been transported to Ontario for disposal, there are no combined treatment, storage, solidification and disposal facilities (TSDF) to treat hazardous wastes in Canada. Separate landfills and incinerators exist in central Canada but no Canadian facility incorporates all of the necessary features. Some TSDFs in Europe are capable of treating the equivalent of the entire hazardous waste stream generated in the Atlantic region. Wastes brought into a TSDF are destroyed by incineration or are neutralized and detoxified as much as possible. The ash and sludges are then buried in a secure landfill where access is strictly controlled. This type of landfill is also lined with impermeable material, to reduce surface and groundwater contamination.

A TSDF would protect environmental quality by limiting the quantity of hazardous material being discarded to the environment through undesirable disposal practices. Unfortunately, the siting of these facilities usually encounters public opposition. Many Atlantic Canadians would be unwilling to see a TSDF located within the Atlantic region. This indicates that the public needs to be further informed about the advantages of proper waste disposal and the low risks involved with a well designed and properly sited TSDF.

3.3.3 Hazardous Waste Contamination — Case Studies

Unacceptable disposal methods such as the use of open burning, sewers or improperly designed landfills can result in the introduction of hazardous wastes to the environment. Waste disposal sites and dumps may also be the source of toxic chemicals reaching the aquatic environment by runoff or leaching into groundwater supplies. (See section 2.1.2.3). By the end of 1984, 782 active and 752 inactive waste disposal sites were located in the Atlantic region[83,84,258,259,260]. There are undoubtedly many more which remain to be discovered. Only 5 of these sites are considered to be properly run landfills which were set up after a comprehensive site evaluation and include limited access, spreading and compacting, and daily cover[261]. Most of the other sites receive indiscriminately dumped garbage, with no method of screening out potentially dangerous or toxic substances. (See section 7.2).

Examples of hazardous waste mismanagement of the magnitude of the Love Canal incident, where 600 homes were evacuated near Niagara Falls, New York, have not been discovered in the Atlantic region. Unfortunately, several cases of contamination from dumpsites have been reported. (See section 2.2.1.6 for a discussion on the Sydney Tar Pond dumpsite). One example of contamination involves lead from an active industrial disposal site in northern Nova Scotia. Soil samples taken at the site have lead concentrations ranging from 1,123 to 8,000 ppm, (600 ppm urban, or 150 ppm rural, is considered excessive for surface soil by the Ontario Ministry of the Environment). Lead has also migrated through a swamp to a nearby stream. Sediments collected downstream have lead concentrations between 70 and 1,780 ppm.

Many of the dumpsites identified in the region contained buried transformers, capacitors or pesticide containers. There is some concern that pesticides or PCBs may have leached from the dumpsites to groundwater supplies or surface watercourses. For example, problems with PCB contamination at the Amherst landfill still remain after the removal of 120 drums of PCB waste in 1978. An estimated 17 tonnes of PCB contaminated waste are still buried at the site. PCB concentrations in topsoil several metres downhill from the dumpsite range up to 210 ppb, considerably higher than the background level of 50 ppb. Very low levels of PCB have also been recorded at the Nappan River, 1.5 km away.

A herbicide drum burial site at CFB Gagetown received considerable media attention in the fall of 1984. Liquid residues were discovered in 112 of 666 chemical drums excavated from the site in December 1984. Residues were composed of the herbicides 2,4-D and picloram, and herbicide contaminated sodium silicate and oily wastes. Concentrations of 2,4-D (up to 56,000 mg/L) and picloram (up to 19,700 mg/L) suggested that the liquids were residues of Tordon 101, a herbicide that has frequently been used on the base since the late 1960s[262]. Little herbicide remained in the soil from where most of the drums were discovered, and although local groundwater systems had been affected, organic contaminants did not exceed maximum acceptable guidelines for drinking water quality[262].

A preliminary field investigation of abandoned disposal sites in New Brunswick indicated that more information was needed to identify potential environmental concern at the Scoudouc (near Moncton), French Village (Rothesay) and Howe's Lake (Saint John) dumpsites. Large quantities of leachate were found moving from the three sites, although local wells were not yet contaminated by the leachate[263]. Further field monitoring is also being recommended for other dumpsites in the region adjacent to watercourses or containing hazardous wastes. These include abandoned coal dumps in Nova Scotia, and smaller agricultural pesticide dumps in Prince Edward Island[84,258].

3.4 Transportation and Storage of Dangerous Goods

Environmental and human health concerns arising from the transport and improper storage of dangerous goods have received considerable legislative and media attention over the past six years. Public interest was heightened in 1979 by the derailment of a train carrying chlorine gas at Mississauga, Ontario, which resulted in the evacuation of 250,000 people[264]. Similar, but smaller scale incidents are not uncommon throughout Canada as an increasing tonnage of dangerous goods are stored or move across the country by road, rail, ship and air.

3.4.1 Transportation

A large percentage of marine cargo handled at the ports of Halifax and Saint John are classified as dangerous goods (Table 24). Petroleum products make up the bulk of these commodities, although shipments of sulphuric acid, sodium hydroxide, asbestos, calcium cyanide and sodium chlorate are significant[265]. In addition, phosphorous is shipped from Long Harbour, Nfld., and turpentine and benzene are shipped from central Canada through the Gulf of St. Lawrence[266]. Reliable estimates are unavailable, but large quantities of petroleum products, sodium hydroxide, sulphuric acid and anhydrous ammonia are also carried by rail. Gasoline, chemicals, paints, and cleaning solvents are transported by road. While many of these items are important to our modern way of life, they can be environmental hazards if they are accidentally released[264,267].

The transportation of potentially harmful products is regulated under the Transportation of Dangerous Goods Act (TDGA) (1980) and its accompanying regulations. The Act consolidates a number of federal regulations covering air, ship and rail movements and provincial regulations for road transport (Table 25). The Act is unique because it establishes a single authority for the handling and transportation of dangerous goods.

TABLE 24

Dangerous Goods Handled at Six Canadian Ports (1983)

Port	Total Marine Cargo (tonnes)	Total Dangerous Goods (tonnes)	% Dangerous Goods of Total Handled
Saint John	8,350,000	5,925,137	71.0
Halifax	12,470,000	7,595,856	60.9
Quebec	15,570,000	121,867	0.8
Montreal	22,740,000	4,751,330	20.9
Vancouver	51,650,000	1,481,224	2.9
Prince Rupert	3,110,000	12,536	0.4

Source: Grochawalski, 1984[265].

Dangerous goods are subdivided into 9 classes under the Act: explosives; gases; flammable and combustible liquids; flammable solids; oxidizing substances and organic peroxides; poisonous and infectious substances; radioactive materials; corrosives, and miscellaneous substances considered to be dangerous to people, property or the environment. A colour-coded system of warning placards and labels has been devised to easily identify potential dangers associated with spilled or discharged products. A preliminary socio-economic study by the Ministry of Transport estimated that industry's compliance costs would exceed $10 million across Canada[269], but it is felt that the potential benefits of environmental protection and reduced clean-up costs make this expenditure worthwhile.

TABLE 25
Provincial Transport of Dangerous Goods Legislation

Legislation	Current Status	Prospects
New Brunswick -Motor Transport Act	Provisions of this Act allow the provincial government to make an agreement with the federal government to regulate the transportation of dangerous goods. No other legislation is considered necessary at this time.	Work is currently underway to make and implement this agreement.
Nova Scotia -Dangerous Goods Transportation Act	Proclaimed, 1982	Federal regulations adopted by reference. No amendments to the legislation are envisioned.
Prince Edward Island -Dangerous Goods Transportation Act	Given Royal Assent, 1981	Proclamation of the Act and adoption of federal regulations by reference are expected shortly, pending the completion of federal-provincial consultations.
Newfoundland -Dangerous Goods Transportation Act	Given Royal Assent, 1982	The Act will be proclaimed and federal regulations adopted by reference, but provincial officials foresee some problems during the regulations and cannot predict firm dates.

Source: Eco/Log Week, Feb. 22, 1985[268].

The Transportation of Dangerous Goods Act (TDGA) also provides for a manifest system which tracks the movement of hazardous wastes from origin to destination. Every generator shipping hazardous wastes must complete a manifest form which upon arrival is checked to ensure that the entire consignment has been delivered. The provincial governments are responsible for the day-to-day operation of this system[270].

A 24-hour dangerous goods information and emergency response centre (CANUTEC) has been established in Ottawa in accordance with the TDGA. CANUTEC has information cards on approximately 30,000 dangerous goods carried worldwide, which facilitates rapid analysis and emergency response. CANUTEC assisted in 30 road, 3 marine, 3 air and 2 rail incidents in the Atlantic region between 1982 and 1984 inclusive[271]. Although accidents do not have to be reported to CANUTEC, regulations under the Act provide for mandatory reporting of dangerous occurrences to the proper authorities (depending on mode of transport and location of the incident).

3.4.2 Storage

There are no federal regulations covering the storage of dangerous goods in immobile storage containers. Chemical storage tanks are a provincial responsibility, and only two provinces in the Atlantic region, Newfoundland and New Brunswick, have regulations which control their use and construction.

In New Brunswick, storage tanks can be considered potential pollutant "sources" under the Clean Environment Act and its 1982 regulations. The regulations provide for the mandatory reporting of polluting incidences and state that new storage tanks (or "sources") must be approved by the provincial Department of the Environment.

The Newfoundland system is geared more specifically to the storage of gasoline and related substances. Under the 1982 regulations of the Department of Environment Act, no person can construct, install or alter a storage tank system without completing a Storage Tank System Application form and obtaining approval from the Newfoundland Department of the Environment. Mandatory reporting of polluting spills is again provided for under these regulations.

3.4.3 Oil and Chemical Spills

In 1984, 433 spills were reported to EPS in the Atlantic region, up from 348 in 1981. Oil and petroleum products accounted for 88% of the

TABLE 26
Significant Events (Spills Greater than 2,275 Litres) 1974 — 1983

Year	New Brunswick	Nova Scotia	Prince Edward Island	Newfoundland	Atlantic Region Frequency	Atlantic Region Quantity (tonnes)
1974	15	56	3	54	128	8,399
1975	39	67	3	84	193	2,134
1976	38	63	6	79	186	4,163
1977	35	23	5	78	141	32,872
1978	33	32	6	86	157	11,041
1979	34	22	1	59	116	9,800
1980	25	31	3	18	77	261,117
1981	33	37	3	31	104	1,844
1982	21	20	13	42	96	2,510
1983	29	20	1	37	87	974
Total	302	371	44	568	1285	334,854

Source: EPS, 1985[272].

total number of spills and 89% of the 1.6 million litres spilled in 1984. PCB solutions, pesticides, industrial wastes and sulphuric acid were also spilled on several occasions. A 763,000 litre oil storage tank spill at Baie Verte, Newfoundland was the largest incident reported to EPS between 1981 and 1984[179].

While the total number of reported spills has increased, the number of spills greater than 2,275 litres (called significant events) decreased in the Atlantic region during the 1980s (Table 26). Newfoundland had the largest number of spills, while P.E.I. had the least. Because of the scattering of a small number of larger spills, there is no clear temporal pattern associated with annual total spill volumes. The high total for 1980 includes several large spills of industrial wastes in New Brunswick[272].

Transportation spills have resulted in adverse environmental impacts in the Atlantic region.

Transportation and storage spills have resulted in adverse environmental impacts in the Atlantic region. In 1982, a 619 tonne diesel spill from an oil storage facility at Baie Verte, Nfld., resulted in the extensive contamination of 2 km of shoreline. Sub-lethal biochemical effects were also observed in locally caught flounder. In 1983, a 900 barrel diesel spill at a fuel depot at Campbellton, N.B., created a series of small slicks which extended for 17 km into the Restigouche River Estuary. A train derailment near Juniper, N.B., dumped several containers of methylene chloride, calcium hypochloride, isopropyl alcohol, zinc oxide, fabric softeners and white mineral oil into the North Branch of the Southwest Miramichi River. This resulted in three large fish kills of Atlantic salmon, trout, suckers, chub and redfish[275]. These are only three examples of the numerous incidents which have resulted in some environmental contamination in the Atlantic region.

Chapter 4
Other Environmental Issues

Summary

The composition of the forests of the Atlantic region has been altered since the early days of European settlement. Extensive clearcutting, coupled with fire control and disease, has resulted in a predominance of balsam fir and spruce, both highly susceptible to spruce budworm attack. The most recent budworm infestation has essentially destroyed the fir and spruce forest of the Cape Breton Highlands, and has resulted in conifer mortality in New Brunswick, mainland Nova Scotia and Newfoundland. Forestry practices in the region have led to the displacement of wildlife, nutrient losses which may affect the long-term productivity of poorer sites and the excessive siltation of rivers and streams. Practices favouring the establishment of pure stands have indirectly led to the increased use of chemical pesticides needed to protect these highly vulnerable stands from insect and disease. Alternative selective cutting techniques may result, in the long-term, in more diverse and resistant stands.

Total energy consumption in the Atlantic region has declined slightly since 1978. Although the use of refined petroleum products declined by nearly 24%, the use of coal rose by 74%. This has resulted in an increase in SO_2 and NO_X emissions from thermal power plants in the region. Other energy sources may not result in adverse air emissions, but may nevertheless result in some environmental concerns. For example, the use of hydro and tidal power development can lead to changes in fish habitat, siltation and fish kills. Nuclear power, which became a reality at Pt. Lepreau, N.B., poses the difficult problem of radioactive waste disposal. Fuelwood combustion for domestic heating, which has steadily grown in the region since 1979, emits CO, particulates and PAH, which could be of concern in modern air-tight houses. Cleaner alternative sources of energy include groundwater source heat pumps, and passive solar energy. Energy conservation should be promoted, because it increases efficiency

of fuel use, decreases the combustion of fossil fuels, and reduces the need for costly, environmentally adverse energy developments.

Recycling can significantly reduce the volume of solid wastes requiring landfill, and the volume of liquid industrial wastes needing disposal. Paper, glass and scrap metal are being recycled in the Atlantic region, although only the recycling of paper has significantly increased since 1979. Some recycling of industrial wastes occurs, but at only 25% of the rate achieved in Ontario.

4.0 OTHER ENVIRONMENTAL ISSUES

The quality of the air and water of this region is influenced by many factors as described in the first three chapters, including various human activities both within and outside the region. This chapter examines two major activities, forestry and energy production, which are important to the economy of the region and have a particularly strong influence on the quality of the environment. Their effect on the environment comes from the massive scale of projects or from their widespread nature increasing their potential for broad impacts. Along with the discussion of energy and energy conservation is a consideration of recycling as a step toward improving environmental quality.

4.1 The Forestry Resource

The forests of the Atlantic Provinces cover a land area of 179,000 km^2 and support an industry worth over $3 billion[274,275]. Although much of the region's land area is classed as productive forests, heavy exploitation and losses to fire, insects and disease may result in a shortage of wood fibre by the turn of the century[276]. Exploitation and insect epidemics also have profound impacts on environmental quality, through the alteration of forest composition, loss of habitat and potential nutrient losses.

4.1.1 Uses of the Forest

Forests have been used for three centuries to provide the raw material for the production of lumber, pulpwood, fuelwood and other products. Although forestry is the most obvious industrial use of our forests, other uses are also important. Over 100,000 hunters are active each year in Nova Scotia alone and further recreational enjoyment is obtained from camping, picnicing, nature photography or the simple enjoyment of walking through the woods[276]. The forests of the Atlantic region are also used for scientific research and education. Educational uses range from formal university field courses to interpretive walks through the woods for young children.

In other words, this variety of uses touches in some way nearly every resident of the Atlantic region, therefore proper forest management practices are not only important to the forest industry, but to all Atlantic Canadians.

4.1.2 Forest Regions

The forests of the three Maritime Provinces are classified under two major regions: the Acadian Forest Region (includes P.E.I., N.S., and most of N.B.) and the Great Lakes — St. Lawrence Forest Region (the remaining northwestern edge of N.B.). Each forest region is further subdivided into a number of ecologically distinct areas with differing forest compositions[277].

The characteristic climax forest of the Acadian Region includes yellow birch, eastern hemlock, white pine and red spruce. Other important species include balsam fir, sugar maple, red pine, black spruce, red oak, white elm, black ash, red maple, white birch, grey birch, trembling aspen and balsam poplar[277]. Within the Acadian Region there are several areas of varying forest composition from predominantly coniferous, through mixed woods, to predominantly hardwood.

The Great Lakes — St. Lawrence Forest Region is also highly diverse and species rich. The northern New Brunswick portion consists primarily of sugar maple, beech and yellow birch on hill tops, with balsam fir and white spruce in the valleys.

The forests of Newfoundland and Labrador are the eastern-most extension of a continuous belt of primary coniferous forest that extends across Canada — the Boreal Forest Region[277]. Only 34% of Newfoundland and 10% of Labrador are classed as productive forest lands, compared to 90% of the Maritimes land area. Much of Newfoundland's productive forest land is found in the Grand Falls area on the plateau of central Newfoundland, and the Corner Brook area in northwestern Newfoundland. These forests are dominated by balsam fir, and black spruce, with some white spruce and scattered white birch[277].

4.1.3 Past/Present Forest Practices

The composition of the forests of Atlantic Canada have changed greatly from their state at the time of European settlement. The 300 year history of forest exploitation, an increase in the incidence of fire, and major losses by disease and insects have had a profound effect on the forest[278,279]. The result has been changes in species composition and distribution to an increase in the fir component because of its natural regeneration following clearcutting[279].

Commercial exploitation from the early 19th century has replaced extensive white pine stands with coniferous and mixed stands of spruce and fir. Extensive land-clearing in P.E.I. has resulted in the loss of high quality deciduous forests (sugar maple, beech, yellow birch) to the agricultural industry. This has also resulted in the growth of coniferous and mixed woods that bear little resemblance to the original forest.

Present forestry practices may also change forest composition. Clearcutting has favoured the regeneration of balsam fir, which has drawbacks in terms of commercial utility and budworm susceptibility[279]. Succession, particularly following clearcutting of high value hardwood, mixed and spruce/pine stands, has frequently been undesirable. Approximately 1/3 of the clearcuts on the Cape Breton Highlands do not regenerate adequately to commercial species in adequate numbers[280]. Clearcuts of fir/spruce stands have resulted in a preponderance of fir regeneration, which is extremely vulnerable to spruce budworm infestations which may require expensive chemical treatment to combat[279].

Clearcutting results in an initial loss of nutrients through the removal of nutrients tied up in the harvested stand, the loss of nutrients bound to eroded soil particles and the accelerated decomposition of litter and organic material on exposed cutovers[281]. Mechanical clearing equipment which eliminates on-site vegetation or results in ground disturbance and redistribution of slash and organic debris, may also redistribute or deplete nutrients. This depletion of nutrients also reduces the soil's ability to buffer acid rain, which may be compounded by the loss of hardwoods, whose deep root systems bring neutralizing agents from deeper soil layers. (See section 1.3). The significance of nutrient losses following disturbances is however, expected to be minor on better quality sites[282].

In the absence of fertilization, the nutrient reserves of a forest build slowly through a natural process which may take up to 100 years. The trend in the Atlantic region towards short-rotation forestry (i.e. a cycle of 40 years) and whole tree harvesting is consequently of concern because of the potential for long-term reductions in forest productivity. Whole-tree harvesting removes additional nutrient-rich material such as branches and tree tops from the site[282]. Whole-tree harvesting can increase nutrient removal by 100-200%, resulting in a possible loss of the productive capacity of the site and the lengthening of the next rotation[283].

Clearcutting reduces cover for many small mammals and birds, leaving them open to predation. Clearcutting may, however, be beneficial to animals such as white-tailed deer, moose and the snowshoe hare, whose principal foods consist of vegetation that normally grows in abundance during the first few decades after an area has been clearcut[282]. Large clearcuts are not utilized by game animals because they lack sufficient cover.

Increased disturbance from logging roads may be of greater concern to some wildlife populations. Shy sensitive species such as lynx, cougar and caribou are particularly vulnerable to such disturbance. Forested areas, because of their remoteness and relatively undisturbed nature, are very important to the continued survival of these species. In Newfoundland, caribou have frequently disappeared from wilderness areas disturbed by human activities. The network of forestry roads have in some cases been known to result in erosion, and the subsequent siltation of local streams can affect fish habitat. Siltation is particularly deleterious to salmon and trout which require silt-free gravel in which to spawn and which are already at risk from acid rain, pollution and over-fishing[284]. (See also section 2.1.1.2.1).

Skidder logging operations have been shown to result in ground disturbance of varying severity on cutovers in Newfoundland[285]. Poor or suppressed growth of softwoods and establishment of weedy broadleaf species has been correlated with severely disturbed or compacted portions of cutovers[285,286]. This site degradation may result in reduced forest productivity over the long term.

The knowledgeable application of available silvicultural techniques (especially the various regeneration cutting methods) could reduce problems which have undesirable successional trends. The shelterwood harvesting system, for example, is an effective method of obtaining spruce and fir regeneration that can also be used to reduce the proportion of fir (or any other undesirable stand component)[287]. This method (which involves cutting strips of trees and allowing conifers to establish themselves between the strips) is also effective in reducing shade-intolerant broadleaf species — the target of herbicide application — to manageable levels. The group-selection system of uneven age management (harvesting of a small group of trees) similarly results in improved species composition and stand density[288]. Shelterwood is used successfully on a small but significant scale in Nova Scotia. In P.E.I., clearcuts tend to be very small because of the pattern of land ownership, and problems with natural regeneration on cutovers are subsequently reduced.

4.1.4 The Spruce Budworm and Other Epidemics

Outbreaks of the indigenous spruce budworm *(Choristoneura fumiferana)* have resulted in conifer defoliation, cessation of growth and widespread mortality of conifers, particularly in the New Brunswick and Cape Breton Highlands. The most recent outbreak has essentially destroyed the spruce and fir forest of the Cape Breton Highlands, killing the equivalent of 15% of the volume of wood harvested in a typical year in Canada[289]. Projections indicate that this may result in a severe wood shortage by the turn of the century and the potential loss of between 4,350 and 5,600 jobs in Cape Breton and northeastern Nova Scotia[289].

The forest conditions most susceptible to spruce budworm damage are extensive, mature fir/spruce stands with a high proportion of fir[290]. Location also plays a role as young vigorous stands may suffer extensive damage if they are located adjacent to or downwind from an infected site[290]. While the short-term economic and wood fibre losses may be significant, over the long-term, by attacking over-mature fir forests, the budworm prevents the perpetuation of old or decadent stands and thus rejuvenates the forest[279].

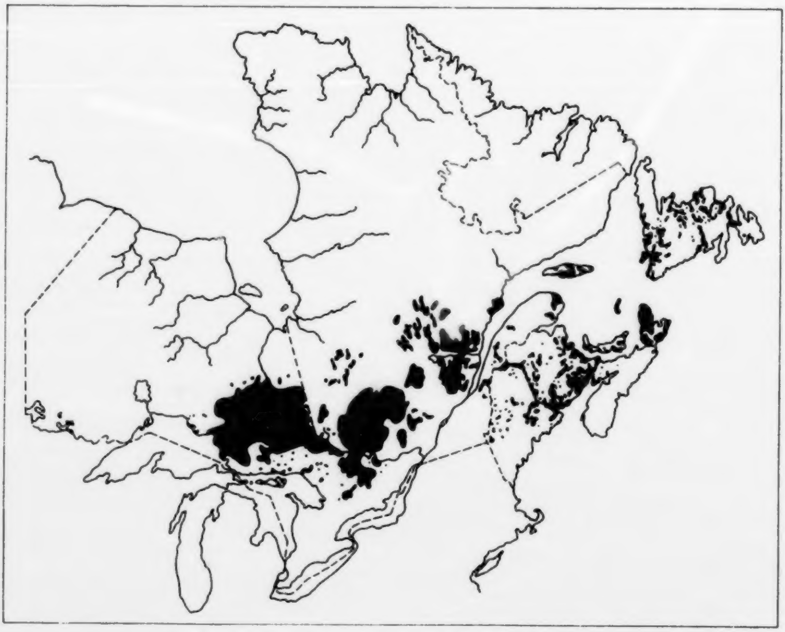


Figure 24 Areas of eastern Canada and Maine, U.S.A. with mortality of Balsam fir and Spruce caused by the spruce budworm (1981)[291]

Spruce budworm epidemics were first recorded in Nova Scotia in 1846, and most probably occurred for centuries before that[276]. During the 20th century, outbreaks were three times as numerous as the preceding century, and coalesced to cover vast regions in Ontario, Quebec and the Maritimes (Figure 24). Maximum defoliation has increased from 10 million ha around 1910 to 55 million ha in the 1970s[279]. Newfoundland, the north shore of Quebec, and Anticosti Island were affected for the first time in the 1970s (from an outbreak which began ten years earlier)[279].

Recent outbreaks may be more severe due to alterations of the forest, which have resulted in extensive stands of budworm host species[279]. In fact, a correlation was observed between the frequency, duration, and severity of budworm infestation with clearcutting, fire protection and herbicide use. The latter forestry practices favour the establishment of fir-spruce stands, thus rendering the forest more vulnerable to budworm attack[279]. Clearcutting and the widespread replanting of white spruce are expected to increase in the future[276]; this may further increase the susceptability of forest stands.

Impacts on wildlife from past budworm infestations have not been documented to any great extent in the Atlantic region. In a review of the impact of the spruce budworm infestation in Cape Breton, only the rare American marten and the American red squirrel were considered to be negatively affected. Among birds, only the rare boreal owl, the Arctic three-toed woodpecker and the more common spruce grouse may have been affected[292]. The rapid development of a shrub layer following stand mortality and the patchy nature of tree fall may compensate for any adverse effects from loss of cover[293].

The method currently being used to limit budworm damage is to periodically apply insecticides to kill larvae, limit defoliation and maintain stands long enough to harvest. While insecticides such as fenitrothion and aminocarb have reduced budworm damage in New Brunswick, they have also had the unfortunate effect of prolonging the epidemic[279]. (See section 3.2.2 for more detail on the environmental implications of forestry insecticides). The release of biological control agents such as *Bacillus thuringiensis* (B.t.) is one alternative to the use of chemical insecticides. B.t. tends to be more selective and less toxic to non-target organisms, but it is expensive to use and does not reduce a stand's vulnerability to future infestations. Long-term and perhaps more cost-effective solutions include the large-scale adoption of alternative cutting practices which favour the natural regeneration of resistant species and result in a more diversified and less vulnerable resource base[284].

Other diseases have also altered forest composition. Birch die-back, a disease which affects white and yellow birch, seriously affected birch trees in Quebec, New Brunswick, Nova Scotia and Maine between 1930 and 1950. This converted many mixed wood stands to largely coniferous stands[279]. White spruce plantations in northern New Brunswick are currently infested with epidemic populations of the spruce budmoth *(Zieraphera canadensis)*. This infestation has proven difficult to control, due to the fact that conventional pesticides have been ineffective[294]. In this instance, a major infestation has resulted from an insect which had previously been considered a minor pest in the region.

4.1.5 Alterations Due to Fire

Fire control programs have also contributed to an increased fir component in the forest, because immediate succession following fire is to species such as jack pine and black spruce, with associated hardwood species such as trembling aspen and white birch[279]. This stage is usually followed by a gradual succession to the more typical boreal and mixed wood forest with increased fir and spruce components. Therefore, prior to successful fire control, extensive stands of pioneer jack-pine and black spruce formed an important part of the forest mosaic[279]. Repeated fires have resulted in fire barrens (called anthropogenic heaths) over large portions of Nova Scotia and southern and eastern Newfoundland[281,195]. Much of the present reforestation effort, particularly in Nova Scotia, is being directed towards planting barrens, which may already be of reduced quality in terms of nutrient reserves and potential productivity.

4.1.6 Aesthetic Quality

The value of the forest goes far beyond a dollar figure[276]. The aesthetic beauty of a forest may mirror one's perceptions of environmental quality. Therefore the argument can be made that clearcut sections and skidder trails are equal to reduced environmental quality. Similarly, even though forests ravaged by the spruce budworm may regenerate into a healthy, younger forest, the sight of thousands of decaying trees gives the impression of a low quality environment. Aesthetic quality can, however, be a point of debate. On the one hand, a diverse, climax forest of white pine, sugar maple and yellow birch may be representative of a high quality environment, while on the other hand, neatly spaced trees on a plantation may be considered a high quality environment by a different observer.

There is little virgin forest left in the Atlantic Provinces; most of what one sees has, for better or worse, been modified by human activities[276]. While some silvicultural techniques temporarily spoil the landscape, the challenge is to produce in the long-term a productive, aesthetically pleasing forest, thus satisfying the needs of both the forest industry and the people of the Atlantic region.

4.2 Environmental Implications of Energy Production

Environmental quality can be profoundly influenced by the fuels used for energy generation. For example, coal and oil combustion may result in acid rain and local air quality problems, hydro power can alter water quality and quantity, and fuelwood use can change the diversity of forest ecosystems and affect local air quality. As technology evolves, the fuels used in our region's energy mix also change. This section examines these trends and their resultant impacts on environmental quality in the Atlantic region.

Government policy, particularly the National Energy Program (NEP) between 1980 and 1985, has had an impact on energy supply and demand in Canada. The NEP helped to accelerate the promotion and use of fuels such as coal, natural gas and wood as alternatives to oil (particularly imported oil). Incentives under the NEP included home insulation grants, transportation pools, and incentives for alternative energy research and development and increased energy efficiency in the industrial and commercial sectors.

4.2.1 Canadian and Atlantic Region Energy Sources

Canada has one of the highest per capita energy demand rates in the world. Several factors, including climate, industrial makeup and a large geographic area, account for this elevated demand[296]. In spite of this, Canada is in the enviable position of being a net exporter of energy. Her vast supplies include western and offshore oil and gas, extensive oil sands, hydro and coal resources and largely untapped potential in biomass, peat, geothermal energy, nuclear, tidal power and solar and wind generation.

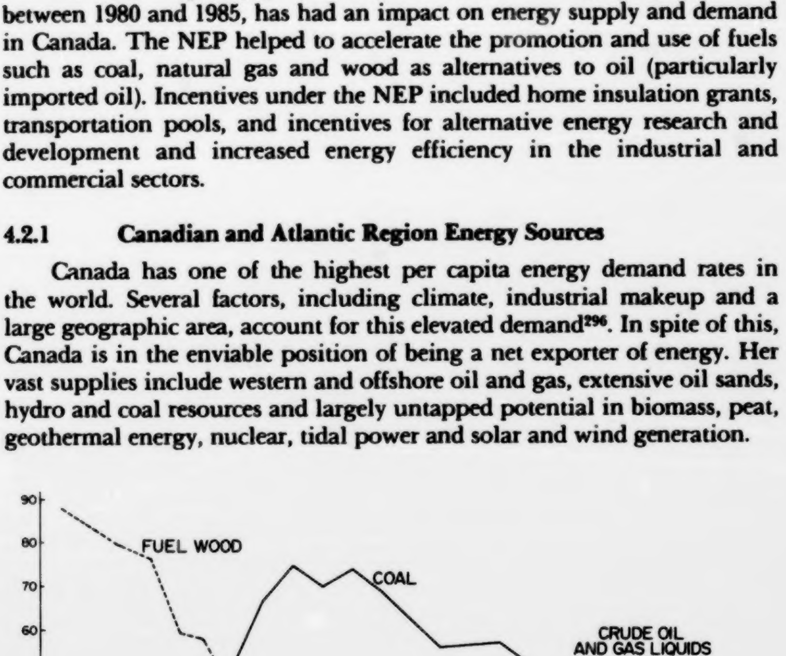


Figure 25 Evolution of primary energy mix in Canada (1871-1982)[296]

Figure 25 illustrates the evolution of the primary energy mix in Canada since 1871. Fuelwood satisfied more than 80% of Canada's energy demand in the nineteenth century. Coal then took over the role of the principal energy supply between 1900 and the mid-1950s. After World War II, oil began its rapid rise to become the most popular fuel source, levelling at over half of the total energy supply in the 1960s and 70s[296]. Several factors helped increase the importance of oil; it was cheap, plentiful, portable, safer to extract than coal and it could be used in all major economic sectors. Although Canada's primary energy mix by the late 1960s was more diversified than in previous decades, oil price escalations in the 1970s made further energy diversification and the off-oil policy the major themes of the national energy policy.

Current dependence on oil is significantly lower than in 1978[23,197]. After substantial increases in energy consumption in the 1960s and early 1970s, Canada's total energy use in 1982 was 3.4% lower than in 1978[23,297]. This small overall reduction in energy use was a result of greater fuel efficiency, the economic recession and higher energy prices. Atlantic Canada experienced similar trends with the use of refined petroleum products declining by 23.7%, and coal use rising by 74% (Figure 26). Electricity use dropped slightly, while natural gas use was insignificant in the Atlantic region[23,297]. The recent growth in coal use in Central and Atlantic Canada could, however, compound the acid rain problem in New Brunswick and Nova Scotia. (See Chapter 1).

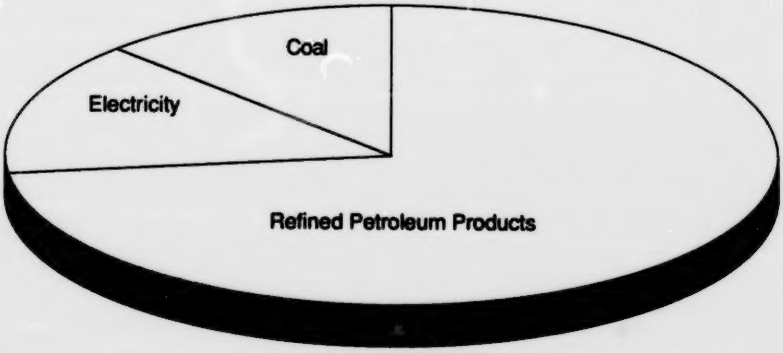


Figure 26 Percentage of energy use by major fuel type in the Atlantic region (1982)[297]

In 1982, the transportation sector was responsible for 33.6%[297] of the total energy consumed by the four major sectors represented in Figure 27. The residential, industrial and commercial sectors were relatively balanced in their total energy needs. The transportation sector's demands were exclusively satisfied by petroleum products, while energy needs in the other sectors were primarily satisfied by petroleum products and electricity.

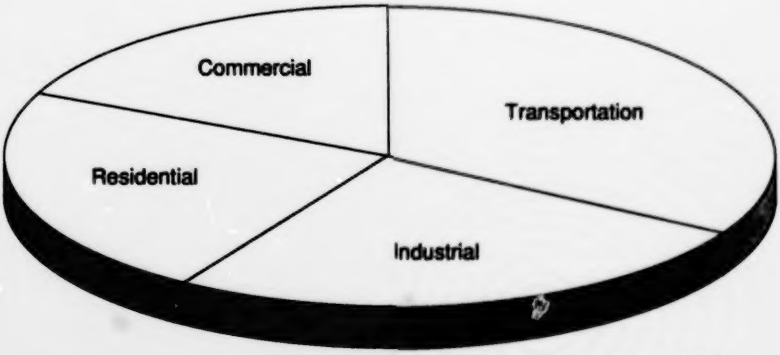


Figure 27 Percentage of energy consumption by sector in the Atlantic region (1982)[297]

Total electricity generation in the Atlantic region in 1982 was 59,274 gigawatt hours (Gwh). Hydro power, with huge resources in Labrador, accounted for 78.9% of the total electricity generated, followed by oil (13.9%), coal (6.9%) and nuclear power (0.4%)[298]. The Point Lepreau, N.B., nuclear generating station was not operating at full capacity, therefore its contribution in 1982 was a tenth of what one would expect in 1984 or 1985. By the turn of the century, the roles of coal and oil may be reversed, as more thermal plants are built or converted from oil-fired to coal-fired generation[299].

4.2.2 Conventional Energy Sources

4.2.2.1 Refined Petroleum Products

Refined petroleum products are produced in the Atlantic region by the Irving refinery in Saint John, N.B., (250,000 barrels per day)[300] and the Imperial (82,000 barrels per day) and Texaco Canada (18,000 barrels per day) refineries in Dartmouth, N.S.[301]. Total refinery capacity in the region was significantly reduced with the shut down of the Come-by-Chance, Nfld., Gulf Oil (Point Tupper, N.S.) and Ultramar (Holyrood, Nfld.) refineries in 1976, 1980, and 1983 respectively[301]. The three existing refineries discharged 87.7 tonnes of oil and grease into the marine environment in 1985[302]. These and other discharges of sulphide, phenols and suspended solids have generally been within regulated limits.

In 1982, heavy fuel oil constituted one-third of the total refined petroleum products consumed in the Atlantic region[297] (Figure 28). The use of heavy and light fuel oils is, however, decreasing due to the increased coal-fired generating capacity in the region and greater oil use efficiencies in the industrial and transportation sectors. The 350 MW Tuft's Cove generating station in Dartmouth[303], the 1,005 MW Coleson Cove station near Saint John[300] and a 150 MW plant at Holyrood near St. John's, are three large oil-fired generating stations in the region. (See Chapter 1).

Although the share of motor gasoline rose to 23.3% of the total refined petroleum products in 1982, the actual amount consumed declined slightly from 1978[297]. This decrease occurred despite a 15.8% increase in the total number of registered vehicles in the region (a 29.6% increase was recorded in Nova Scotia), from 1,007,669 registered vehicles in 1978 to 1,166,902 in 1982[304,305]. Greater fuel efficiency in today's smaller, lighter and more aerodynamic automobiles is the primary reason for the drop in gasoline demand[306].

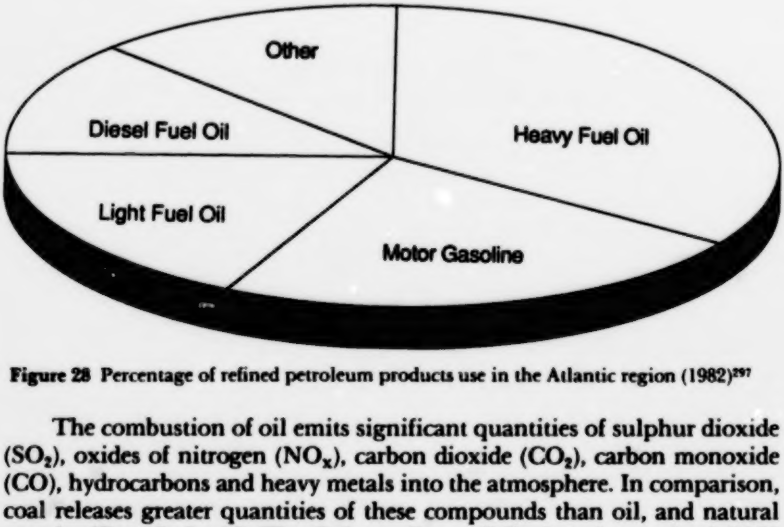


Figure 28 Percentage of refined petroleum products use in the Atlantic region (1982)[297]

The combustion of oil emits significant quantities of sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons and heavy metals into the atmosphere. In comparison, coal releases greater quantities of these compounds than oil, and natural gas significantly less[307]. The Coleson Cove oil-fired station emitted 2,823 tonnes of particulates, 44,150 tonnes of SO_2, 6,950 tonnes of NO_2, 104 tonnes of hydrocarbons and 542 tonnes of CO in 1982. However, coal-fired plants in the region emitted greater quantities of SO_2 and/or NO_x. (See Chapter 1). SO_2 emissions from the Tuft's Cove and Water Street stations in Halifax have contributed with other Halifax area sources to the acidification of local lakes. Sulphur deposition and lake acidification have been correlated with distance from sulphur emitting sources in the Halifax area[308]. (See Chapter 1).

4.2.2.2 Coal

Coal is primarily used in the Atlantic region for electricity generation, with smaller quantities used in the industrial and commercial sectors. Coal resources in Nova Scotia are estimated at 3.2 billion tonnes by far the largest reserves in all of eastern Canada[301]. In 1981, Nova Scotia produced 2.5 million tonnes of coal and New Brunswick produced 566,000 tonnes[309]. Coal use is expected to increase and eventually stabilize at 22% of the Atlantic region's energy demand, and 40% of Nova Scotia's demand, by the late 1990s[299].

The coal used at the Lingan generating station, located near New Waterford, N.S., will displace 6 million barrels of oil per year when operating at its full 600 MW capacity[303]. The 210 MW Trenton, N.S., station, the 200 MW Dalhousie 2, N.B., station and 100 MW generating stations at Grand Lake, N.B., and Glace Bay, N.S., are the other major coal-fired units in the region[309,301].

The increased use of coal in electrical generation could lead to significant environmental impacts. Coal mining can lead to "acid drainage", which may lead to reduced water quality and cause fish kills. Acid drainage from the Minto coal mine in New Brunswick has resulted in the elimination of sensitive aquatic organisms in receiving waters[79]. Transportation of coal releases dust particles which can contribute to local air and water pollution. Acidic runoff from coal cleaning can lower the pH and increase toxic metal concentrations in receiving waters. Wash water and runoff from the Minto, N.B., coal preparation plant in the late 1970s left 6 km of stream devoid of streamside vegetation and aquatic life[79].

Major contaminant plumes are found in the soil and underlying bedrock at the Victoria Junction coal cleaning plant, and the Nova Scotia Power Corporation's dry ash landfill at Lingan. In addition, 2 wells have been contaminated north of the Gardiner Mines abandoned waste rock dump[99]. (See Chapter 2).

Coal combustion, due to its sulphur content, contributes significantly to the formation of acid precipitation[307]. Some local coals are high in sulphur and contain significant amounts of lead, chromium, aluminum, uranium and arsenic, which can be concentrated in the ash[310]. Emissions of SO_2, NO_x and particulates could produce local adverse environmental effects and health problems, such as an increase in respiratory ailments, damage to sensitive species of vegetation, aesthetic problems and material damage to buildings, metals and paints[307].

High stacks often reduce local impacts, but contribute to the long range transport of air pollutants. Ambient air monitoring in the vicinity of urban thermal power stations indicates that concentrations of SO_2 and NO_x are generally within acceptable ranges[307]. Based on ambient air quality data, SO_2 levels close to the Lingan plant are not expected to cause any problems under normal weather conditions[311].

New combustion technologies are being tested at Summerside, P.E.I., Pt. Tupper, N.S., and at Chatham and CFB Gagetown, N.B. These new coal burning methods (including fluidized bed combustion, coal and water slurry, and limestone injection burner) will substantially reduce SO_2 and NO_x emissions from coal-fired plants.

The combustion of coal and other fossil fuels is a major factor in increased global carbon dioxide levels. CO_2 levels are rising at about 0.3% per annum, possibly contributing to a universal warming of the earth's surface. This phenomenon, called the "greenhouse effect", may have pronounced climatic effects, including increasing sea levels, which could affect the Atlantic region in the future. These changes may became so significant as to warrant limits to the combustion of fossil fuels, particularly coal[307].

4.2.2.3 Hydro Power

Hydro power accounts for 79% of the total electricity produced in the Atlantic region[298]. Newfoundland generated 92% of the total hydro electricity in the region in 1982, while in contrast, Prince Edward Island had no hydro capacity, and Nova Scotia and New Brunswick generated most of their electricity from thermal stations. Much of the electricity generated in Labrador is exported to Quebec and is, therefore, unavailable for regional consumption. It is estimated that by the year 2000, hydro power will constitute 71% of the total regional electrical generation[299].

The 5,225 MW Churchill Falls, Labrador, generating plant is by far the largest electrical generating facility in the Atlantic region[312]. Other hydro developments in the Atlantic region are small in comparison and include the Mactaquac, N.B. (600 MW), Wreck Cove, N.S. (200 MW), and Baie D'Espoir (450 MW) and Twin Falls (200 MW) generating stations in Newfoundland[313]. Most potential for developing future generating capacity is located in Labrador, with lesser potential on the island of Newfoundland, New Brunswick and only limited potential in Nova Scotia[312].

Hydro power displaces the combustion of fossil fuels for energy generation, therefore it can be beneficial in improving air quality. Although hydro stations do not produce SO_2, NO_x, waste heat or nuclear wastes, they can adversely affect fish and wildlife[309]. For example, hydroelectric development on the Saint John River has reduced the river's capacity to assimilate wastes, thus resulting in fish kills due to oxygen depletion in the head ponds[314]. Suspended sediments and reduced light penetration inhibiting photosynthesis can result from erosion, slumping within the flood zone and the temporary formation of new beaches by wave and ice action[315].

Hydro power accounts for 79% of the total electricity produced in the Atlantic region.

Fish habitat may be destroyed (or enhanced) in the reservoir or in streams between the dam and the tailrace outflow. Hydro dams often become physical barriers to fish migration, either reducing access to spawning areas or damaging fish which stray into intakes and pass through the turbines. Seaward migrating Atlantic salmon juveniles have suffered significant injury from turbines at the Mactaquac dam, thus potentially reducing adult numbers. Populations of shad and striped bass have declined due to reduced access to upstream habitat. In contrast, alewife, blueback herring and white sucker populations have increased due to an increase in habitat in the Mactaquac impoundment[314].

Hydro developments, particularly those in Labrador, are often located in remote locations. Long transmission corridors are, therefore, required to bring the electricity to market. Potential adverse effects from transmission lines include: the loss of productive forest or agricultural land; disturbance from the construction of access roads; siltation at stream crossings; tree blowdown at right-of-ways; loss of salmon and wildlife habitat, and the accumulation of pesticides in watercourses. Many of these concerns will be addressed in an environmental protection plan being produced by Newfoundland and Labrador Hydro for future transmission corridors.

Other concerns include ozone production, noise and the occurrence of electrical fields. The last three factors have not yet been found to exceed levels which would have adverse effects on biological communities[315].

4.2.2.4 Nuclear Power

Nuclear power generation became a reality in Atlantic Canada when the Point Lepreau, N.B., CANDU reactor was declared in commercial service in January 1983. More than 50% of Lepreau's 680 MW output is licensed for export to New England, and at the end of 1982, over 30% of the plant's capacity was under contract for export[298].

The likelihood of a major accident at a carefully designed and maintained nuclear reactor is small[316], although public apprehension, stimulated by incidents such as the Three Mile Island accident in 1979 is much higher. In a 1980 survey in New Brunswick, 36% of the respondents felt that the Pt. Lepreau nuclear station was a safe enough facility, while 46% thought the existence of the plant posed too many risks. (Only 5% stated it was completely safe)[317]. The CANDU reactor is, however, twice as efficient as the American Light Water Reactor, and unlike its American counterpart, is able to use natural uranium, thus eliminating a complex step in the production of enriched uranium[316].

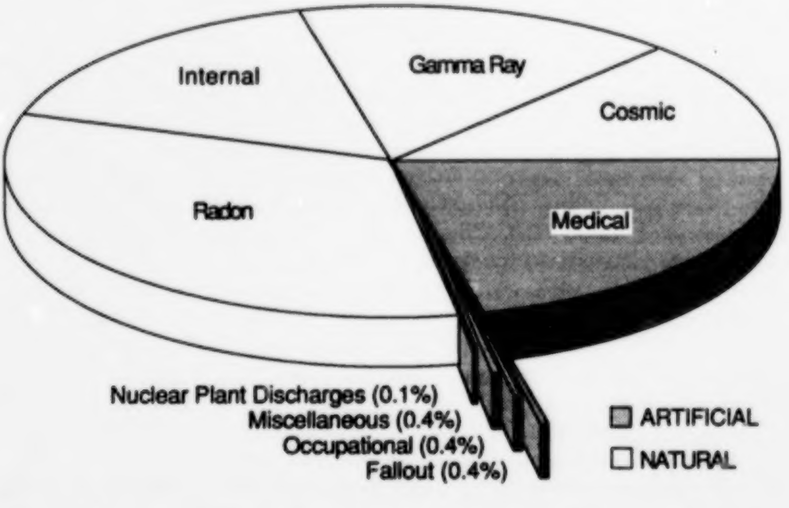


Figure 29 Percentage of radiation doses from natural and man-made sources[319]

The effect of low level radiation on human populations is not fully understood, although higher level carcinogenic effects have been documented. Most low level radiation is emitted from natural sources such as rocks and building materials. Non-natural sources include x-rays, atmospheric nuclear tests, television sets and nuclear power plants. In the 1970s, less than 1% of a person's normal dose of radiation was from nuclear generation, although this varied geographically from 0.1% to over 50% (Figure 29)[318]. Monitoring in the vicinity of the Pt. Lepreau station indicated elevated radioactivity only in 1981, which was interpreted as fallout from a Chinese nuclear bomb test in October 1980.

Approximately 6,000 tonnes of used fuel, 1 billion tonnes of low-level radioactive wastes and 120 million tonnes of uranium tailings have been generated in Canada[287]. Radioactive wastes are not only generated by nuclear plants, but also in hospitals, research facilities and industrial plants[318]. The disposal of nuclear wastes, which are persistent in the environment, poses a problem. Most nuclear waste is in temporary storage. Permanent disposal of wastes and spent fuel may be possible in stable crystalline rock common to the Canadian Shield[318]. Radioactive waste from the Lepreau station is stored on-site.

4.2.2.5 Natural Gas

Natural gas was the second largest source of energy in Canada in 1982. In contrast, its use was insignificant in the Atlantic region. Only one small field is in production in the region, the Stoney Creek field in New Brunswick, which produces enough gas to supply approximately 500 residential and 35 commercial customers in the Moncton area[300].

The National Energy Board estimated that natural gas use in the Atlantic region would rise to 9.6% of the total energy demand by the year 2000. Nova Scotia and New Brunswick were expected to use western natural gas transported via the Trans-Quebec-Maritime pipeline. This development will likely never reach the construction stage due to economic considerations, but it may be replaced by gas from the Venture field in the late 1990s.

Natural gas is the cleanest burning fossil fuel and emissions are generally restricted to CO_2 and NO_x. These emissions are relatively low. Coal produces 75% more CO_2[307] and 25% more NO_x than natural gas[318].

4.2.3 Alternative Energy Sources

Canada's off-oil policy has sparked an increase in the research and development of other energy sources that could eliminate our future dependence on imported oil and other non-renewable sources of energy. Although energy sources such as wood fuel, peat combustion and tidal power can result in adverse environmental impacts, other sources such as solar power and geothermal energy tend to be more environmentally benign. Prince Edward Island, because of its small size and lack of conventional energy resources is expected to lead the region in the development of renewable energy sources.

4.2.3.1 Wood

In the 1950s and 1960s, fuelwood was relegated to the status of an insignificant local supply of energy[296]. Recently, due to the high cost of oil, wood and other biofuels have begun to be rediscovered by people across Canada, and their use has now risen to 3% of Canada's total primary energy supply. Wood fuel is becoming particularly important for domestic and industrial space heating.

Canada's forests generate approximately 100 million tonnes of damaged or unutilized growth each year, the equivalent of 25% of Canada's primary energy demand[320]. The total potential wood fuel in the Atlantic region is estimated to be 12,508 tonnes, most in the form of dead or damaged trees, logging residues and surplus wood[320]. This wood fuel has the potential to replace 1,350,000 barrels of oil, if problems such as transportation and storage costs can be overcome.

There is also some controversy over whether or not large tracts of land should be used for agriculture or the production of other wood products. Increased use of wood for fuel can lead to stiff competition with the pulp and paper or lumber industries. In addition, wood fuel is often a side product of mixed forest harvesting. This resource may slowly disappear in the long-term, due to clearcutting and reforestation, which may lead to a predominantly coniferous forest. (See section 4.1).

Hog fuel (wood residue such as sawdust, shavings, bark, etc.) is the most important source of wood energy in the industrial and commercial sectors. Wood residues are particularly important in New Brunswick, accounting for nearly 5% of the total primary energy demand. Most of this energy is supplied by hog fuel boilers in pulp mills, which generate electricity and process heat. The Fraser Inc. pulp and paper mill in Atholville, N.B., has a 15 MW wood-fired steam generator, which results in 90% electrical self-sufficiency and the displacement of over 108,000 m^3 of oil per year[321].

Wood-fired power plants could also be important local supplies of energy. One small plant in Fredericton, N.B., supplies electricity for the University of New Brunswick, a hospital, a Transportation Department garage and two seven-storey apartment buildings. Several wood chip burning units have been installed in Prince Edward Island. The largest unit burns 12,000 tonnes of wood chips per year to heat the University of Prince Edward Island and the Veterinary College in Charlottetown.

Other smaller units heat the King's County Memorial Hospital and the provincial administration complex[322].

Domestic fuelwood production in 1981 in the Atlantic region was slightly greater than 1 million cubic metres, or 20% of the Canadian total. This represented an increase of 10% over 1980[323]. During the 1982-83 fiscal year, 30,583 oil furnace units were converted to wood in the Atlantic region as part of a federal government incentive program[298,321]. The four Atlantic Provinces expected a modest rise in fuelwood use up to 1985, followed by a levelling off of residential fuelwood demand.

Wood burning emits more particulates but less SO_2 and CO_2 than fossil fuels. In 1980, 20,609 tonnes of particulates were estimated to be emitted in the region due to fuelwood combustion. (This was 4 times higher than in 1978). However, ambient air sampling conducted in Truro and Lower Sackville, N.S., where 45% of households burn fuelwood, indicated that particulate levels were low[9]. Other environmental concerns include the loss of wildlife habitat from an increased harvest operation and water quality effects, such as increases in sedimentation, logging debris and nutrient loadings[320]. (Environmental effects associated with the harvesting of wood and wood wastes are described in greater detail in section 4.1).

Wood stoves can also be substantial emitters of CO, particulates, and a wide variety of organic compounds, including acids, aldehydes, phenols and polycyclic aromatic hydrocarbons (PAHs). PAHs are frequently adsorbed onto the surface of respirable-size wood ash particles. Inefficient combustion of moist wood and restricted air flows are two factors which contribute to wood smoke and CO emission. (See Chapter 1). More efficient stoves, which effectively control or slow down combustion tend to form creosote in chimneys, constituting a fire hazard[320].

4.2.3.2 Energy From Municipal Waste

Municipal waste is a significant potential source of energy, particularly in urban areas. Energy is generated from waste incinerators located in Hamilton, Quebec, Montreal and Charlottetown. The Charlottetown, P.E.I., plant, operational in February 1983, displaces more than 20,000 barrels of imported oil per year[324]. In addition, 80 tonnes of municipal waste per day, which would normally be landfilled, are reduced to 10% of the original volume. The plant converts waste to steam, which is used by two hospitals located within 1 km of the plant[321].

The Charlottetown facility emits small amounts of hydrochloric acid and heavy metals, but appears to have a negligible impact on local air quality[325]. A more comprehensive monitoring program, the National Incineration Testing and Evaluation Program (NITEP), will attempt to correlate combustion conditions with trace emissions of dioxins, furans, heavy metals, and other contaminants.

4.2.3.3 Biogas

Biogas is a mixture of methane and carbon dioxide. It is produced from agricultural wastes and other biomass, such as animal manure, some aquatic plants, sewage sludge and food processing wastes[296].

Biogas can be used in cooking stoves, internal combustion engines or for the generation of electricity. Although biogas is used only in small quantities in Canada, it has widespread use in the People's Republic of China, India and Southeast Asia[318]. The major environmental problem associated with biogas production is a high content of heavy metals, pesticides and nutrients in wastewater from the digestion process.

A program was initiated by the Metropolitan Authority of Halifax to extract methane gas from the Mt. Uniacke landfill to potentially replace 25,000 barrels of oil annually[326]. However, actual quantities of methane were found to be much smaller than anticipated, and the project has been cancelled.

4.2.3.4 Liquid Alcohol Fuels

Methanol and ethanol are liquid alcohol fuels which can be produced from wood and other biological resources. The most significant potential use of alcohols is as a 10-20% blend with gasoline, commonly called "gasohol". Alcohol fuels are feasible because they are portable and completely biodegradable, they have a suitably high energy content, burn cleaner than petroleum fuels, and have a higher octane rating than pure gasoline with no additives[296]. Further research, and the development of an effective distribution system is required to expand the use of liquid alcohol fuels in Atlantic Canada.

4.2.3.5 Peat

Peat is partly decomposed organic matter, made up principally of decayed sphagnum moss. Peat can be considered a non-renewable energy source, because several thousand years are needed for its formation. Canada is second only to the USSR in proven peat reserves; Canadian reserves of 22.7 billion tonnes of fuel peat contain the energy equivalent of 1.3 billion cubic metres (8.2 billion barrels) of oil[296]. While most peat is located in remote locations, New Brunswick and Newfoundland both contain an estimated 250 million cubic metres of fuel peat. If developed, 3.2 to 7.2 million cubic metres of oil (20.1 to 45.3 million barrels) could be displaced in each province[299].

Peat is not yet actively used for electrical generation in Canada, but the USSR has 6,000 MW of peat-fired electrical generating capacity, and one-third of Ireland's thermal generating capacity is peat-fired[296]. Both New Brunswick and Newfoundland may use peat in their future energy plans. For example, Shippegan bog in New Brunswick could support a 40 MW station as a baseload operation[327].

There are several important environmental implications in both the harvesting and combustion of peat. The harvesting of peat can disrupt local hydrological regimes and damage sensitive wildlife habitat. Heavy metals tend to concentrate in peat and then be emitted during combustion[310].

4.2.3.6 Tidal Power

Energy from tides is not a new concept, in fact, tidal mills in Europe were in operation as early as the 12th century. There are three tidal power stations currently in operation: a 240 MW plant at La Rance, France; a 0.4 MW plant in the Soviet Union, and a 17.8 MW plant at Annapolis Royal, Nova Scotia[328], which began production in April, 1984. The plant at Annapolis is part of a project designed to test the low head STRAFLO turbine which may be used in the proposed Bay of Fundy tidal project. The Annapolis site was chosen because a tidal barrage had already been built there in 1961, and the impounded basin provided adequate water storage.

Ten percent of the larger striped bass passing through the intake at the Annapolis station could be killed by the turbine, which could result in significant mortality, since the fish are expected to repeatedly pass through the turbine to feed or spawn. Shad, Atlantic salmon and alewife are not expected to suffer significant mortality[329].

Surface and subsurface drainage of important agricultural lands in the western Annapolis valley could be altered by the scheme, although land would not be lost due to flooding. Improved tidal gates and control structures across ditches and channels have been installed to mitigate most adverse drainage effects. Bank erosion at productive marshes has previously been a problem and could be accelerated by increased water level fluctuations[329].

Two sites are considered to have potential for producing electricity at a competitive cost in the upper reaches of the Bay of Fundy. The Cobequid Bay site would have an optimum generating capacity of 4,864 MW and an annual energy output of about 14,000 Gwh. The other site, in the Cumberland Basin, would have an installed capacity of 1,140 MW, annually producing up to 3,400 Gwh of electricity. Most of the electricity generated would be exported to markets in New England and New York; 1,200 Gwh per year would be retained for use in the Maritimes[330].

Although tidal power is a "clean" form of energy generation, significant environmental impacts could result from a dam constructed at either site. Water behind the barrage could become stratified, resulting in warmer surface water in the summer and thicker ice cover in the winter, leading to local microclimatic effects. The reduced tidal range could create an intertidal zone about half the present size behind the dam, reducing the extent of the mud flats, that are important feeding sites for migrating birds and fish. Siltation in the headpond and the transport and deposition of mud in the Minas Basin could impact on benthic organisms and scallops at Georges Bank, and the outer Bay of Fundy could be affected by an increase in the transport of bottom sediments[328,331].

Models suggest that tidal barrages in the upper Bay of Fundy could bring the Bay of Fundy — Gulf of Maine system into resonance with the natural tidal cycle. The Cobequid Bay barrage may increase tidal ranges at the New England coast by up to 20 cm. This could result in coastal flooding and the modification of currents and mixing characteristics in several New England estuaries. Increased estuarine tidal mixing, coupled with enhanced upwelling in the outer Bay of Fundy could result in positive environmental effects, such as increased primary productivity[328].

4.2.3.7 Solar Energy

Solar energy has little environmental impact and can displace other less desirable, non-renewable sources of energy. Passive solar energy for space and water heating contributed 1.5% of Canada's primary energy supply in 1980[296]. With the aid of government subsidies and extensive research and development, passive solar heating could supply a significant portion of the energy needed for space heating by the year 2000[306]. Passive solar heating is actually a form of energy conservation, because it promotes efficient energy use in the residential and commercial sectors.

Active solar heating systems differ from passive systems in that heat is transferred through the system by pumps and fans. In addition, heat is stored in a device other than the building mass[296]. Active solar heating is expensive, and improvements in technology are required before it can significantly contribute to energy supply. Although Canada receives sufficient annual quantities of solar radiation, comparatively little is received during the winter, the normal peak demand period[296]. In 1978, active solar energy was an insignificant proportion of Canada's energy mix. Optimistic projections indicate that active solar heating may satisfy 8-9% of space heating requirements by the year 2000[306].

4.2.3.8 Wind-Generated Electricity

The highest average wind speeds in inhabited areas of Canada occur in the Atlantic region, therefore, commercial or domestic wind generation may be a feasible alternative source of electricity. Although wind-generated electricity may not be continuous, more sustained supplies would be generated during stormy winter months, thus coinciding with periods of peak demand. Although wind generators are essentially clean and may replace fossil fuels, problems with wind generation include noise, aesthetics (due to the generator's large size) and interference with communication signals[296].

Wind generation facilities have been installed in Newfoundland, Nova Scotia and New Brunswick[296]. The largest in Nova Scotia is a 280 kw (0.28 MW) turbine used to pump water at the Wreck Cove hydroelectric generating station in Cape Breton[303]. Prince Edward Island could be the site for future developments, as a suitable site for a 6 unit wind farm with a 2,000 kw (2 MW) total capacity is being sought. Wind could supply up to 10% of peak electricity demand in Prince Edward Island by the year 2000[332].

4.2.3.9 Geothermal Energy

Geothermal energy refers to the heat or energy which can be extracted from naturally occurring steam or warm water found in certain geological zones. Although most potentially commercial sources are located in British Columbia, water in the 30-50°C range could be used for space heating along the Cumberland Basin in the Atlantic region.

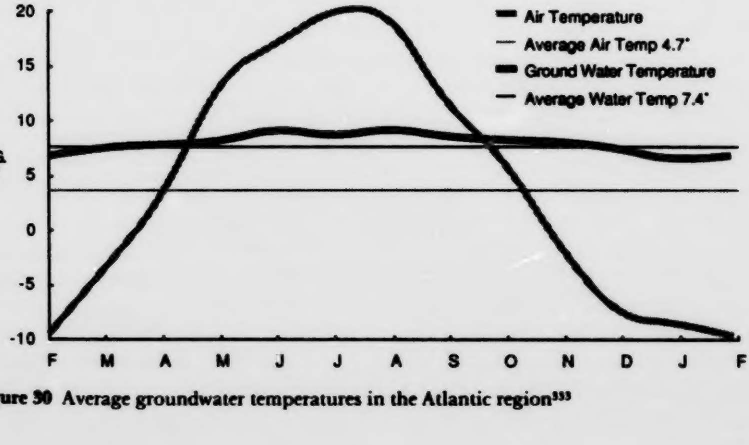


Figure 30 Average groundwater temperatures in the Atlantic region[333]

This sedimentary basin runs through northern New Brunswick, Prince Edward Island, northern Nova Scotia and Cape Breton island. Studies are underway to examine the feasibility of tapping this resource at abandoned coal mines.

The greatest potential for geothermal energy in the Atlantic region lies with the use of groundwater source heat pumps (GSHPs). GSHPs extract heat for space heating from groundwater with a temperature above 5°C. Although surface air temperatures fluctuate over the year, average groundwater temperatures in the region remain at a constant 6-8°C (Figure 30). Therefore, with the exception of Labrador and northern Newfoundland, GSHPs can be effectively used anywhere in the region with aquifers capable of sustaining wells with yields greater than 0.4 L/sec. More than 75% of the wells surveyed in the region had yields in excess of this flow[334].

Numerous GSHPs are already operating in homes throughout the Maritime Provinces, and are proving that this form of alternative energy is plentiful, cheap, renewable and reliable. GSHPs are also environmentally safe, because they offer a clean, combustionless heat, and used water can be returned to the aquifer via a recharge well. GSHPs can result in a 60% saving on annual heating costs and can be reversed for use as an air conditioner in the summer[335].

4.2.4 Energy Conservation

Conservation is the easiest, least expensive and most environmentally beneficial method of satisfying energy demand. Energy conservation reduces the need for the combustion of fossil fuels, or the construction of large hydro projects in remote areas, therefore air quality can be maintained and wilderness areas preserved even during periods of economic growth. Conservation does not imply a reduction in the standard of living, but implies greater efficiency with less overall consumption of energy. The evolution of the television set is a good example of this principle. State of the art television sets use a small fraction of the energy consumed by earlier sets, and in addition, the quality of the picture and the reliability of the product has been significantly improved[296].

In a series of six surveys conducted between 1975 and 1980 in larger cities across Canada, an increasing number of Canadians claimed that they were engaged in energy conservation activities[336]. Most urban Canadians indicated they would support a variety of government conservation programs, with financial incentives being the most popular. One highlight of the report was that residents of Halifax showed the most concern regarding the energy situation[336]. Despite this concern, about 60% of Atlantic Canadians perceive that the energy consumed in their homes has increased over the past 5 years.

4.2.4.1 Transportation Sector

Automobiles and light trucks accounted for 31% of the 1978 Canadian oil consumption, 51% of the energy use in the transportation sector, and 17% of Canada's total energy use[299]. In 1978, the average Canadian car used 14.6 litres of fuel per 100 km. In 1985, the average new car was estimated to use less than 8.4 litres per 100 km. Exceptionally efficient small cars on the Canadian market in 1983 and 1984 consumed as little as 5.0 litres per 100 km[306].

Electrical powered urban vehicles may be cost effective by the turn of the century. Alternative fuels such as methanol or an alcohol-gasoline mix could further reduce petroleum demand. Although the total number of automobiles and kilometres driven will increase, the total energy consumed by automobiles will decrease, and the demand for petroleum products may be significantly reduced[306].

Energy savings are also possible in marine transportation and the commercial fishery. For example, a wooden trawler in New Brunswick recently fitted with an efficient ducted propulsion system will save 45,000 litres of diesel oil per year, representing a 15-20% reduction in fuel consumption[309]. Other energy conservation measures, including converting from gasoline to diesel fuel, cleaner hulls and new hull designs, could reduce vessel energy requirements 25-40% by the year 2000.

4.2.4.2 Residential and Commercial Sectors

There is great potential for energy conservation in the residential and commercial sectors, since approximately 30% of Canada's energy consumption is for heating and cooling of air or water in homes, stores, shopping centres, offices, schools, hospitals, sports arenas, factories and warehouses[306]. Energy efficiency can be increased through the use of windbreaks, insulated night shutters, double or triple window glazing, or the removal of north facing windows. Modern, airtight, well insulated homes consume as little as 10-20% of the energy required by houses built to older standards[296]. Even practices such as washing clothes in cold water can eliminate 10-25% of the demand for domestic hot water.

The commercial sector as well has significantly improved energy efficiency since the 1973 oil price escalation. Commercial buildings constructed in the 1980s use 10-20% less energy for heating, cooling and lighting than their predecessors, and some older buildings have undergone modifications or retrofitting to be more energy efficient. For example, three retrofitted hockey arenas in New Brunswick saved a total of $27,000 per year in energy costs[309]. If this was applied to all of New Brunswick's 83 ice arenas, then their annual energy costs would be reduced by three-quarters of a million dollars. If other commercial structures used similar energy saving technology, the Atlantic region's dependence on the combustion of non-renewable fossil fuels would be further reduced.

The buildup of CO, CO_2 and other air contaminants can occur in buildings with low air exchange rates. A dangerous buildup of toxic chemicals could also result if a wood stove is used to satisfy energy requirements in this type of structure. An air-to-air heat exchanger will result in proper ventilation without the loss of excessive amounts of heat[296].

4.2.4.3 Industrial Sector

Although more efficient energy use is expected to occur in the pulp and paper and petrochemical industries, fewer conservation gains are expected from high quality heat consumers such as steel mills. Recycling and more efficient uses of finished products can significantly decrease energy demand, and reduce the volume of solid waste which would be landfilled or discharged to the environment. (See section 4.3). Energy savings of 25 to 50% will result from paper recycling[337], and the use of waste heat for space heating can also significantly reduce energy demand. For example, by the year 2000, it is estimated that Canadian industry will use 32% less energy to produce the same type of product that was produced in 1978[306]. Energy audits by the Prince Edward Island Enersave program estimate a potential 25% energy reduction per commercial or industrial client using current technology[338].

4.3 Recycling

Recycling is a relatively recent development in North America because it has traditionally been cheaper to discard used goods and replace them with virgin materials. There are, however, two major reasons for encouraging the re-use of waste material. The first is that new products are often cheaper to produce from recycled material, due to the elimination of several steps in the production process. Secondly, recycling reduces the quantities of wastes which require disposal, thus decreasing the area required for landfills. In Canada, 7% of municipal wastes are being recovered for energy generation or re-use; this figure could increase to 40-50% and theoretically rise to almost all of the total solid waste stream[339].

4.3.1 Solid Waste Recycling

There are two basic approaches to waste reduction. One approach is to decrease the quantity of wastes entering the solid waste stream by increasing the longevity of products, encouraging the use of refillable packages or reducing the quantity of required packaging[339].

The second approach is to retrieve wastes after the final user has rejected them. One method tried has been to allow the elements of mixed wastes to be reclaimed or burned for heat recovery. The more common method is to retrieve hand or mechanically segregated components such as paper, glass and metal containers for reprocessing and re-use[339].

Scotia Recycling of Halifax is the largest collector of paper in the Atlantic region. Currently 12,000 tonnes are collected annually, representing a 70% increase from 1979. Several dealers recycle smaller quantities of paper in Prince Edward Island, New Brunswick, and Newfoundland. Paper is also recovered from federal government establishments in Halifax-Dartmouth, N.S., Bathurst, N.B., and CFB Gagetown, N.B. A company in Fredericton, N.B., has recently received a federal/provincial grant to recycle paper, glass, metals and plastics. Markets are readily available for the 130 tonnes of material expected to be recovered annually[340].

Domglas Inc., a glass manufacturer based near Moncton, N.B., is the sole recycler of glass in the Atlantic region. Although Domglas Inc. can process all the container glass generated in the region, it receives less than 10% of recoverable glass. Most glass is collected from nearby areas in New Brunswick and Nova Scotia. None is collected in Newfoundland, due to high transportation costs, and little would be collected in Prince Edward Island, due to shipping costs and a recent ban on non-refillable beverage containers.

The 300 members of the Canadian Association of Recycling Industries (CARI) collect most of the scrap metal recycled in Canada. In 1981, CARI collected approximately 9 million tonnes of scrap materials resulting in sales of $1.5 billion[339]. In the Atlantic region, 3,500 tonnes of aluminum; 7,000 tonnes of lead; 2,500 tonnes of copper; 2,500 tonnes of brass; 80,000 tonnes of iron; 50,000 tonnes of car bodies and 10,000 tonnes of cast iron were collected in 1983 (estimated amounts)[341]. Most of this material was sent to central Canada for reprocessing. This quantity represents a modest 5% increase over 1978. CARI estimates that at least 25% more metals can be recovered from landfill sites in the region.

4.3.2 Industrial Waste Recovery

Incentives for industrial waste recycling are not limited to government sponsored funding programs. Recycling in many cases is less expensive than waste disposal. The cost of industrial waste disposal may continue to rise as new legislative provisions for higher levels of treatment, perhaps requiring sophisticated abatement equipment, are introduced. (See section 3.3 — Hazardous Wastes). In addition, by recycling wastes directly on the premises, a firm is able to significantly reduce the purchase of new materials. Waste reduction and recovery may thus become more attractive than waste disposal, often directly contributing to a company's profit. For example, the 3M Company's international pollution prevention program saved $17.4 million in 3 years, and Monsanto Chemicals has been marketing by-product chemicals with a long-range potential income of $350 million[342]. Savings of this magnitude do not exist in the Atlantic region, but the recovery of metals and solvents in smaller industries such as photoprocessing and dry cleaning is commonly practiced.

In 1983, less than 5% of liquid industrial wastes were recycled in the Atlantic region, compared to 18% in Ontario[256]. The transportation and disposal of industrial wastes can be simpler and less expensive if their volume is small. In addition, fewer hazardous substances would be discharged or accidentally leached to watercourses if they are continually re-used. Re-use, or in some cases incineration for heat recovery, would also make economic sense when compared to disposal costs.

Recycling of hazardous wastes in the Atlantic region is not widespread. Mercury is recovered for re-use at the CIL chlor-alkali plant at Dalhousie, N.B., and a small quantity of metals (zinc, nickel, gold), and processing solutions are recycled at surface finishing plants within the region. Local petroleum refineries re-refine slop oil and waste oils from other processes, and also remove expensive catalysts. A plant at Belledune uses sulphuric acid from the nearby lead smelter to combine with other products to produce fertilizer. Alkaline sludges are not recovered from acetylene manufacturers which is unfortunate, as they could be used to neutralize acidic effluents from nearby industries.

Approximately half of the Atlantic region's 68 million litres of used lubricating oils are available for recovery. Re-refining of waste oils is less expensive than refining virgin stock, because the lubricating components present in the used oil simplify the refining process. Twenty-five to 30% of recoverable used oil is being collected in the region, but most is being used on roads for dust suppression. The use of oil in dust suppression is potentially damaging to the environment, as used oils may contain elevated levels of metals, PAHs and PCBs. The remainder is either dumped, landfilled, or used as industrial fuel. A re-refinery in Toronto purchases some used oil from the Atlantic region. Dustbane Ltd. processes used oil with sawdust and sand in their cleaning product, and some greenhouses in the region employ used oils for heating.

Wastewater can also be recycled, which is particularly important in areas of limited freshwater supply. Wastewater from one operation may be clean enough to serve as a water input in another process. It may also be economically beneficial to recover constituents and recycle wastewater, rather than simply treat it for discharge[342].

The pulp and paper industry uses more water than any other industry in the Atlantic region. Seventy-five to 150 m^3 of water are used per tonne of newsprint produced and 100 m^3 are used per tonne of kraft pulp (approximately 57,000 m^3 of water per mill per day) for digesting and cooking wood chips and washing pulp. Every mill recycles much of its wastewater, although the Bowater Mersey mill in Liverpool (newsprint) and the Irving mill in Saint John (kraft pulp) use the least amounts of water per unit of product[343].

4.3.3 Waste Exchanges

There are occasions when on-site recovery of waste or surplus materials is not feasible in the manufacturing process. In these cases, the transfer of wastes to industries which require these substances may be of mutual benefit. In order for a transfer to occur, companies must be aware of each other's requirements. This is accomplished through a waste exchange, which acts as a broker amongst industries. A waste exchange attempts to match waste generators with waste users, thereby linking potential trading partners[342].

Two waste exchanges are active in the Atlantic region. The Canadian Waste Materials Exchange, operated through the Ontario Research Foundation, is a national information exchange which lists wastes generated or required for 3,700 companies (140 are in the Atlantic region). Approximately 17% of the listings are presently transferred annually, representing approximately 215,000 tonnes of waste (187,000 tonnes in 1981), at an estimated replacement value of $6.5 million. Unfortunately only 12 transfers have involved Atlantic companies since the inception of the program in 1978[344]. Alkaline wastes used to neutralize acidic waste streams are the primary industrial wastes exchanged in the region. Most industries throughout the region have not yet chosen to participate in the exchange, despite possible economic and pollution abatement benefits.

EPS has instigated a very informal exchange in which surplus laboratory chemicals are transferred amongst local hospitals, laboratories, high schools and universities in the Halifax-Dartmouth area. EPS, in cooperation with the Nova Scotia Department of the Environment, distributes lists of available chemicals to local institutions and arranges collection times. On average, 12 small chemical transfers (largest value $10,000) are completed per year, primarily in the Halifax-Dartmouth area[345]. Although these efforts are small in scale, they illustrate that waste exchanges are a feasible method of reducing the need for hazardous waste disposal.

Chapter 5

Human Health and the Environment

Summary

Although the annual means of all five conventional air contaminants monitored in the region are mostly below maximum acceptable values, several short-term values exceed the tolerable levels which may threaten human health. There is particular concern over: the possible increase in cancer rates at Sydney, N.S., due to coke oven emissions; lead poisoning from automobile emissions; the inhalation of asbestos dust at Baie Verte, Nfld., and respiratory problems from excessive dust levels at Labrador City/ Wabush. While there may be a link between cancer and air emissions at Sydney, emissions of lead are declining, and there is little evidence of ongoing health problems for the residents of Baie Verte or Labrador City.

Health risks related to the spraying of chemical insecticides and herbicides on forests in New Brunswick have been the focus of three provincial task forces. They determined that there was no evidence to support a link between spraying and Reye's Syndrome, cancer or birth defects. There may, however, be an association between the intensive use of agricultural chemicals and certain birth defects in the Saint John River Valley.

Chronic symptoms of arsenic poisoning have been found in approximately 30% of the consumers of water from contaminated wells near Waverley, N.S. Contamination of wells from leachate at landfills and from pesticide applications may become increasingly common, particularly in Prince Edward Island. Some pollutant health problems have been reduced. For example, intestinal diseases from the consumption of contaminated shellfish have been reduced since the shellfish approval program was initiated in the early 1970s. Although

a lobster harvesting ban has been lifted for Belledune Harbour after five years, a similar ban continues for the South Arm of Sydney Harbour.

5.0 HUMAN HEALTH AND THE ENVIRONMENT

Environmental protection policy ultimately strives to maintain an environment favourable to human health. Indicator organisms such as mussels, fish, lichens or birds are relied upon to warn us of environmental degradation and the potential for human health effects. Many of the substances discussed in this report are toxic to most biota and have potential human health effects. Only those that have been shown to have reached levels in the environment which exceed recommended health standards, or have been strongly suspected of causing human health effects in this region, are included in this discussion.

There have been few firmly established cases of cause-effect human health impacts resulting from environmental pollution in the Atlantic region. Nevertheless, there have been a number of situations where the risks appeared high and actions were taken to prevent any possible harm.

5.1 Atmospheric Exposures

The Clean Air Act provides the legislative basis for the federal government's air pollution control activities. Its primary objective is to protect the health of the public of Canada from air pollution. Maximum tolerable objectives have been established for the "conventional" air pollutants (SO_2, TSP, NO_2, CO, O_3) and regulations are specifically set to limit the amounts of certain hazardous air pollutants from specific industrial sources[2].

The annual means of all five conventional parameters, monitored at urban locations throughout the Atlantic region between 1974 and 1983 are well below the maximum tolerable objectives and generally show declining trends. (See also section 1.1). The exception is suspended particulate matter at the Whitney Pier station in Sydney, N.S., which is adjacent to the Sysco steel plant. Mean values here consistently exceeded the (U.S.) maximum tolerable objective up to 1981 (there being no Canadian objective), and a large percentage of the recorded values continue to exceed this objective.

Although annual mean total suspended particulate (TSP) values for all other stations in the region are mostly below the acceptable objective, many of the recorded values frequently exceed the tolerable objective limits for short periods of time (Figure 3). The health implications of the latter have not been specifically investigated, although a health study carried out in Sydney in 1976 found a small but statistically significant connection between respiratory function in school children living in Sydney and the degree of air pollution in the locality where they lived and went to school[346].

There is also concern over emissions from the coke ovens which contain elevated levels of PAHs. A number of individual PAH compounds including benzo(a)pyrene (BaP), for which there is sufficient evidence of carcinogenicity in experimental animals and humans, have been measured at high concentrations in air samples taken downwind of the Sydney plant. (See section 1.1.1.1). This is of particular concern given the toxic nature of BaP and the fact that the Sysco coke ovens were operating at less than 50% capacity during the study period[8]. It is strongly suggested that one could be exposed to high levels of PAHs at certain sites in the city and that this situation has likely been present over most of the 85 year history of the Sysco plant operation[347].

The lowered lead content of gasoline is reflected in reduced amounts of lead in the ambient air.

Concerns were expressed over long-term exposure to PAHs leading to a high rate of cancer in residents in the exposed community. The death rates in Sydney for all causes of cancer are 25-33% higher than the rest of Canada, or the entire province of Nova Scotia. The elevated mortality rate for all causes of cancer in Sydney appears to be primarily due to mortality from digestive tract cancers, particularly stomach cancer. Stomach cancer rates for Sydney are about twice as high as those of Halifax[348].

Both lung and stomach cancers have been the types of cancer most frequently associated with the adverse effects of air pollution, but the significance of the higher rates of lung cancer in Sydney is masked by the fact that Nova Scotia has one of the highest per capita rates of smoking in the country. Despite the existing data, there is still insufficient evidence to establish a direct causal link between chronic PAH exposure in Sydney and high stomach cancer rates. Nevertheless, given that coke oven emissions are considered to be potentially hazardous to human health, the cancer mortality rates for Sydney cannot be ignored[347].

The use of wood stoves is increasing rapidly in the Atlantic region. The available data on levels of particulate matter and PAHs in communities with heavy wood stove use does not however, suggest a public health hazard, as current levels are relatively low in comparison to areas outside the region with suspected problems (Table 3)[9]. (See also sections 1.1.1.1 and 4.2.3.1).

Despite reductions in ambient lead levels throughout the 1970s, National Health and Welfare advised Environment Canada in 1982 to further reduce human exposure to lead from automobile emissions to protect the health of Canadians. Chronic exposure to atmospheric lead usually affects the brain and nervous system and may result in behavioural and learning disturbances in children. As a result, Environment Canada amended the leaded gasoline regulations to reduce lead in gasoline from the current standard of 0.77 g/l to 0.29 g/l by 1987. The new standard should result in reductions of over 60% from 1982 levels, and represents an overall reduction of close to 80% from the pre-regulation level of 12,000 tonnes in 1972[18]. Ambient lead levels in the Atlantic region have been steadily declining since 1974. (See section 1.1.6).

Inhalation of asbestos fibres has been shown to seriously affect the lungs and result in respiratory dysfunction. Concern over these effects was raised in the early 1970s by residents of Baie Verte, Nfld., where an asbestos mining and milling complex has been in operation since the 1960s. Atmospheric concentrations of asbestos fibres in the Baie Verte area in 1974 and 1975 exceeded air quality objectives for this contaminant. An extensive air pollution control clean-up program at the mine/mill complex was subsequently undertaken, and by late 1979, the major sources of asbestos emissions were under control. Efforts are continuing at the complex to reduce dust emissions, thereby further reducing public exposure and potential health impacts. (See section 1.2.3).

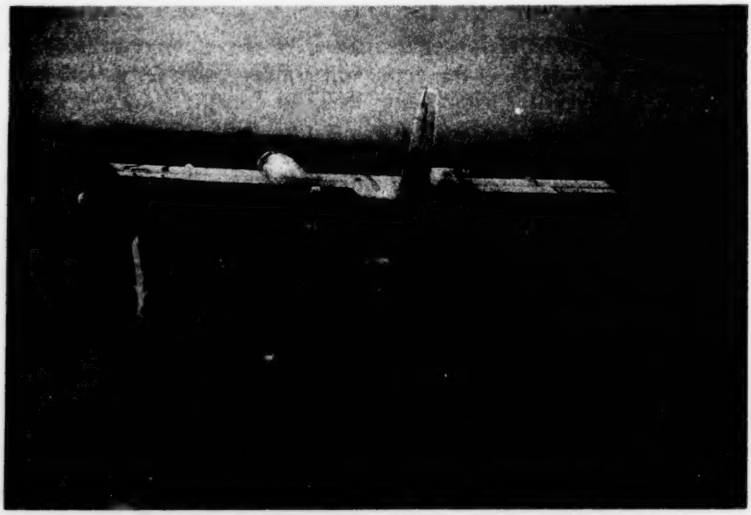
The Labrador City/Wabush region of western Labrador has been a major centre of iron ore mining and concentrating since the early 1960s and represents the largest single source of suspended particulate matter in the region. Occupational exposure to excessive dust levels resulted in 57 identified cases of pneumoconiosis (the accumulation of dust in the lungs and the non-cancerous reaction to its presence) in the workforce at the two facilities since the mines began operation. Despite the fact that short-term air quality in certain sections of Labrador City has not been in compliance with provincial air quality regulations, a one year community air quality study in 1980 found no evidence that the general respiratory health of the residents of Labrador City and Wabush has been affected by mining, processing or waste disposal operations[6]. Control efforts to reduce both emission and fugitive sources of dust at the facilities are being undertaken. (See section 1.1.1).

5.2 Forest Spray Chemicals

In recent years, there has been increasing concern about possible human health risks resulting from the aerial forest spray program conducted in New Brunswick each spring since 1952, to combat spruce budworm infestation. The program relied initially on DDT and then, when the dangers of DDT became apparent, switched in the late 1960s to other chemicals, mainly fenitrothion and aminocarb. In addition, the phenoxy herbicides 2,4-D and 2,4,5-T have been aerially sprayed in forests to control plant growth. 2,4-D is also used in agriculture and in the maintenance of railway and power right-of-ways. (See section 3.2).

During the 1970s, attention to human health risks was directed toward Reye's Syndrome (a condition characterized by fatty degradation of the internal organs of children, often resulting in death). It was hypothesized that the apparently high incidence rates of the disease in New Brunswick were related to viral enhancing properties of emulsifiers used to mix the spray chemicals. In 1976, a panel appointed by the Minister of Health in New Brunswick was unable to find direct linkage between Reye's Syndrome and forest spraying, but recommended that further studies be conducted. In 1982, the New Brunswick Department of Health established a Task Force on Chemicals in the Environment and Reye's Syndrome which again found no evidence to support an association between Reye's Syndrome and forest spraying, but did express reservations about the use of certain emulsifiers and recommended several precautionary measures[349].

Further concern has been expressed about the possible links between chemical spraying and cancer and birth defects. The New Brunswick Department of Health established two Task Forces in this regard. The New Brunswick Task Force on the Environment and Cancer concluded that a causal relationship between spraying and any cancer excess has not been established. The weight of evidence of toxicological evaluations (to 1982) does not support a conclusion that either fenitrothion or aminocarb is carcinogenic to humans. However, the evidence is incomplete for both these active substances. With respect to non-active ingredients (used in the spray formulation to dissolve or dilute active ingredients so they can be sprayed), there is a paucity of data, but short-term mutagenesis studies were all negative. No long-term carcinogenicity studies on mammalians have been reported on non-active ingredients. Questions about the safety of these ingredients, which are usually petroleum derivatives, cannot be set aside. The epidemiological analyses performed by the Task Force suggest that the population of New Brunswick has not experienced a major increase in total cancer rates. There is, however, an apparent increased incidence of certain types of cancer in New Brunswick compared to Nova Scotia, and associations with the spray programme cannot be ruled out[350].



Chemical spraying to control the spruce budworm has been conducted in New Brunswick since 1952.

The provincial Task Force on Chemicals in the Environment and Human Reproductive Problems in New Brunswick, compared trends in reproductive vital statistics for New Brunswick with several other provinces. Stillbirth and perinatal mortality rates were consistently higher (though not by much) in New Brunswick, as were rates for neural tube defects (anencephaly, and spina bifida).

Assessments of teratology and reproductive toxicity were carried out for the insecticides fenitrothion and aminocarb, the phenoxy herbicides 2,4-D and 2,4,5-T and its inevitable contaminant 2,3,7,8-TCDD. There was no evidence that fenitrothion or aminocarb might lead to reproductive problems (although information was very limited). Animal studies on 2,4-D provided no toxicological evidence of teratogenic or reproductive risk; however, 2,4-D is a weak mutagen and has the potential to cause chromosomal damage. TCDD (dioxin, a contaminant of 2,4,5-T) is mutagenic in some test systems, has a weak chromosome damaging effect, is teratogenic in mice at very low doses, reduces fertility in rats, and has produced reproductive abnormalities in rhesus monkeys[351]. All products which contain 2,4,5-T have since been banned by Agriculture Canada.

In 1981, an ad-hoc federal-provincial committee issued a report of a study on the experimental use of Agent Orange (a defoliant used in Vietnam containing both 2,4-D and 2,4,5-T) in Camp Gagetown, N.B., during 1966 (500 litres were used over 10 ha). The committee was unable, from the data available, to find evidence of adverse effects on human health, although the study pointed out the need for properly designed epidemiological studies of human exposures to defoliants[351].

An association has been demonstrated between higher rates of neural tube defects (spina bifida without hydrocephalus) and potential agricultural chemical exposure, which appears to be concentrated within the prime agricultural areas of the Saint John River Valley and northern New Brunswick counties. While there is insufficient evidence to judge whether this is a causal relationship, clearly this possibility must be recognized. The occurrence of problems such as stillbirths and birth defects is believed generally to be the result of a combination of factors. The variety of chemicals used in agriculture is greater than in forestry, and the former industry poses greater potential for direct and indirect human exposure and improper use. (See section 3.2.3). House and garden pesticide use too, although only a fraction of the amounts used in forestry and agriculture, could represent the most significant direct human exposure of all categories considered. Exposure results from storage and use of these chemicals in and near living spaces, combined with the usual lack of protective measures in the home[352].

5.3 Drinking Water

Drinking water is one of the main routes by which many toxic substances enter the body. The Guidelines for Canadian Drinking Water Quality have been established by the federal Department of Health to protect human health. Within these Guidelines are "acceptable" limits for certain contaminants which, if their concentration in drinking water is exceeded, are capable of producing deleterious health effects.

Drinking water in the Atlantic Provinces is supplied from both surface and groundwater sources. Public water supplies in the region generally provide water that meets the "acceptable" limits of the Guidelines, but some fail to do so on a regular basis, a situation which causes great concern. For instance, colour, a natural feature of many water supplies in parts of New Brunswick and Nova Scotia, is usually higher than the objectives. Although primarily an aesthetic problem, the organic compounds responsible for colour can, with chlorination, produce chlorinated hydrocarbons (e.g. trihalomethanes), which are a significant public health concern. (See section 2.1.2). It is only in recent years that this factor has come under detailed investigation[59].

Arsenic contamination of wells in several communities in Halifax County has been documented over the last decade, with many water samples exceeding the maximum acceptable drinking water guideline of 50 ng As/ml. (See section 3.1.1.4). In at least 10% of the samples analyzed, the contaminant level was approximately ten times the maximum acceptable limit, and in 23% it was approximately five times the permissible limit. Chronic symptoms of arsenic poisoning were found in approximately 30% of the consumers of water from contaminated wells in Waverley, N.S.[353]. Arsenic contamination can result in central nervous system disorders, skin lesions, cancer, and possibly liver cirrhosis and heart disease.

A study of private wells in rural Nova Scotia found that concentrations of other metals such as cadmium, zinc, copper and lead increased in water that remained in metal pipes for several hours. Some 50% of the homes studied exceeded Canada's recommended 1.0 mg/L maximum permissible limit for copper, and 20% exceeded the 0.05 mg/L guideline for lead. On average, concentrations of copper, zinc and lead increased by factors ranging from 5 to 22 when water remained overnight in pipes. Because of the high concentrations of copper and lead found in samples of standing water, it is recommended that residents in homes with metal piping allow the water in the pipes to flush for several minutes before use in the morning, or if the water has not been used for several hours[354].

Increasing examples of groundwater contamination have been appearing in recent years. Leachate from a landfill and the pesticide aldicarb have recently been found in municipal wells in P.E.I. and domestic wells in New Brunswick. Although the contamination is not at levels considered harmful to human health, its presence is indicative of the potential hazard. Given that P.E.I. depends totally on groundwater for its drinking water, contamination of this resource can be linked directly with potential health concerns. Contamination of wells with gasoline throughout the region from leaking underground storage tanks, and its potential threat to human health, is a growing concern.

The Department of National Health and Welfare operates a national environmental radiological surveillance program which includes 3 stations in New Brunswick (Edmundston, Fredericton, Moncton). Natural radioactivity levels in treated drinking water at these stations are consistently at or near the limits of detection, and 2 to 3 orders of magnitude below the recommended maximum allowable concentrations in drinking water (Ra226 — 1Bq/L; Uranium — 20 ug/L)[355].

5.4 Shellfish Contamination

The harvesting of oysters, clams and mussels is an important industry in the Atlantic Provinces, but is only permitted from waters of high quality (i.e. where levels of fecal bacteria are below a given level or the waters are free of paralytic shellfish poison). (See section 2.2.2.1). The potential health hazard from consuming shellfish harvested from waters contaminated with bacteria is particularly high because shellfish are often eaten raw or partially cooked. Some diseases which can be contracted from eating contaminated shellfish include infectious hepatitis, typhoid, cholera, salmonellosis, gastroenteritis, and *Vibrio parahaemalyticus* infection. In 1972, there were 478 cases of gastroenteritis reported in Quebec from oysters harvested from Caraquet Bay in northern New Brunswick. The oyster fishery was consequently suspended and since that time, shellfish growing areas must be approved prior to harvesting shellfish for human consumption. There have been no major outbreaks of intestinal diseases attributed to shellfish harvested from approved growing areas since then[118].

Shellfish growing areas along the Bay of Fundy coasts are periodically closed to shellfish harvesting because of the presence of paralytic shellfish poison (PSP), which is produced by the dinoflagellate *Gonyaulax excavata*. This organism "blooms" in warm weather to create what are called "red tides". When the red tide washes clam beds, the shellfish strain the organisms from the water in great numbers, accumulating the poison. A consumer of shellfish with high PSP toxins may develop a condition that can start with numbness of the tongue, lips and body extremities, and can lead to difficulty in breathing, paralysis and possibly death (one half a microgram can be fatal to humans). (See section 2.2.2.1). Caution must be exercised when harvesting or buying shellfish, and attention paid to the location of closed beds.

Industrial discharges are also responsible for contamination of commercially important shellfish in this region. Lobster fishing in the south arm of Sydney Harbour, N.S., and in Belledune Harbour in northern New Brunswick has been closed by the Department of Fisheries and Oceans (DFO) in the past 5 years, as a result of the identification of levels of contaminants in lobsters, which presented a substantial risk to human health. The lobster fishery in Belledune, which was closed due to cadmium contamination from the lead smelter, was opened again in 1985 on the basis of improved effluent treatment and greatly reduced contamination.

Similar success has not been achieved in Sydney. The lobster fishery in the south arm of Sydney Harbour, N.S., was closed in 1982 due to the identification of contamination by PAHs. An investigation of possible sources determined that the "Tar Pond", which has over the past 85 years received the wastes from the Sysco coking plant, was the major source. Extracts of a number of waste flows from Sysco have been demonstrated to be mutagenic in laboratory tests.

Approximately 100,000 — 150,000 pounds of lobster have traditionally been harvested annually from the South Arm over the years, with 50% of the catch being marketed locally in Sydney and North Sydney. With the closure only in effect since 1982, the potential health effects of past consumption of these contaminated lobsters is of concern. An epidemiological investigation would be extremely difficult in this area, due to the small number of people potentially affected, and numerous other complicating factors[356]. Fortunately, discharges from the plant have been greatly reduced in recent years (due to production slowdowns), and engineering studies on how to eliminate and/or control further discharges from the tar pond have just been completed. (See section 2.2.1.6).

Chapter 6
Nature Conservation

Summary

National parks, migratory bird sanctuaries, wildlife management areas, ecological reserves, provincial parks and provincial game sanctuaries all offer varying degrees of wildlife and habitat protection. The most notable recent conservation achievement in the region has been the establishment of 12 federal wildlife management areas over the past 8 years. These sites are owned and managed by the Canadian Wildlife Service and offer full legislative protection from adverse development. Although 3 provinces in Atlantic Canada have passed ecological reserves legislation since 1976, progress towards the establishment of these reserves is slow. By the end of 1984, only 16 of 176 sites identified by the International Biological Programme have actually been protected as permanent or provisional ecological reserves. With few exceptions, provincially designated game sanctuaries do not offer legislative protection from development, or for habitat preservation, although there are often restrictions on hunting and trapping. In addition, provincial parks, unlike national parks, tend to be committed to recreation, and not wildlife conservation.

6.0 NATURE CONSERVATION

Canadians are aware of the importance of nature conservation and wildlife protection. A national survey conducted in 1981 by the Canadian Wildlife Service found that 83.8% of the 100,000 Canadians surveyed participated in some form of indirect wildlife related activity[357]. Twenty per cent undertook special trips to observe or photograph wildlife. With the exception of Nova Scotia, the Atlantic region tended to lag behind the national participation rate in wildlife related activities, although Newfoundland and New Brunswick led the nation in percentage of active hunters.

Eighty percent of Canadians noted the importance of maintaining abundant wildlife, and 82% indicated that it was important to protect endangered species. These results, consistent across Canada, suggest that

Canadians support programs that protect wildlife and their habitat. They also suggest that there would likely be public support for new, more comprehensive wildlife conservation programs in the future[357].

This chapter will review federal and provincial initiatives to protect natural areas and wildlife habitat. The roles of non-governmental organizations will also be assessed. The first section examines programs developed by Parks Canada and the Canadian Wildlife Service. It is followed by a brief description of the International Biological Programme and provincial programs to establish ecological reserves.

6.1 Federal Protected Areas

6.1.1 National Parks

National Parks provide the best form of federal protection for natural areas in Canada[358]. National parks are based on the conviction that places of natural and cultural significance constitute a national inheritance which should be protected for future generations. The federal government has affirmed, since 1885, that outstanding scenic resources should be publicly owned[360]. The year 1985 marked the National Parks Centennial, which included a number of programs throughout Canada which further heightened Canadians' awareness of their natural heritage.

An increase in the number of visitors to national parks in the 1950s and early 1960s led to a growing concern about park protection and management. As a result, national park policies published in 1964 and updated in 1979, emphasized the protection of natural resources, wildlife interpretation, educational activities and professional planning. This protection is legislated under the National Parks Act.

Parks Canada has divided Canada into 39 terrestrial, and 29 proposed marine natural regions. In the Atlantic region, 9 terrestrial regions represent the Appalachians and Canadian Shield physical areas and 3 marine regions represent the Atlantic Coast. Natural areas identified within each natural region are referred to as "representative natural areas of Canadian significance". Potential national parks are selected from them. Eventually, it is hoped that each natural region will be represented by a national park[360].

Park management plans attempt to maintain the physical and biological environment in as natural a state as possible. Rare ecosystems, sensitive natural habitats, International Biological Programme sites (to be discussed later) and other special natural areas are all incorporated into management plans. Traditional resource exploitation occurs in some parks (e.g. small scale wood cutting in Gros Morne), but it is controlled under the park management plan.

Natural processes are allowed to continue unless they have been subject to human-induced changes or are threatening important resources such as endangered species. Monitoring programs are conducted to identify undesirable trends and to document the environmental effects incurred by park development[360].

Park planning regulates land use in national parks. Parks are divided into 5 zones, ranging from highly developed park service areas to zones of special preservation, where access is strictly controlled or prohibited. This system ensures that special areas are given maximum protection from human interference.

There are national parks in each province and territory, covering 1.3% of Canada's land mass. Thirty-one national parks are now established in Canada, including 7 which cover a total of 0.8% of the Atlantic region (Figure 31). In 1983, 4,460,000 people visited the 7 Atlantic national parks, a 19.4% increase over the number of visitors in 1978. Gros Morne (1,943 km²) is by far the largest national park in the region (Table 27), although Prince Edward Island National Park, the smallest national park (18 km²), had the largest number of visitors (1.6 million).

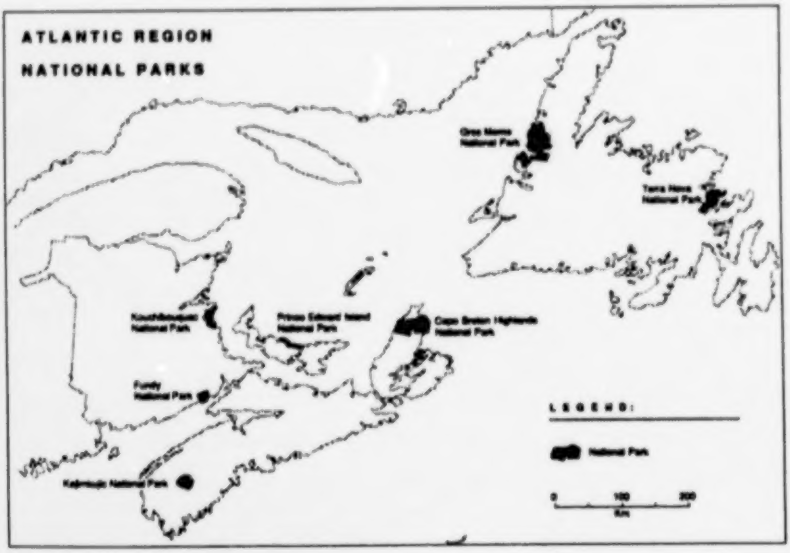

ATLANTIC REGION
NATIONAL PARKS
Gros Morne National Park
Terra Nova National Park
Kouchibouguac National Park
Prince Edward Island National Park
Cape Breton Highlands National Park
Fundy National Park
Kejimkujik National Park
LEGEND:
National Park
0
100
200
km

Figure 31 National parks in the Atlantic region[361]

The West Isles area of the Bay of Fundy is being considered as Canada's first national marine park. In addition to conservation of the marine environment, recreational activities such as boating, hiking, Scuba diving and nature interpretation excursions could be developed. Traditional activities such as the commercial fishery would be continued, although development would be controlled under park management guidelines. The completion of comprehensive feasibility studies and extensive public consultation will be necessary before this potential marine park becomes a reality.

TABLE 27
National Parks in the Atlantic Region

Name	Location	Year Established	Area (km²)	Major Habitats	Principal Wildlife
Fundy	Bay of Fundy, New Brunswick	1948	205.9	Large tides, cliff face, highland plateau	Small mammals, coyote, Atlantic salmon, migrating shorebirds and songbirds
Kouchibouguac	Eastern New Brunswick	1969	225.3	Beaches, dunes, salt marshes, bogs, fields	Nesting terns, osprey and piping plover, migrating shorebirds
Cape Breton Highlands	Cape Breton, Nova Scotia	1936	950.5	Bogs, dry barrens on plateau, coniferous forest	Mammals, pine marten, songbirds and shorebirds
Kejimkujik	Southwest Nova Scotia	1968	381.5	Mixed forests, lakes, freshwater wetlands	Resident mammals, woodpeckers, owls, scarlet tenager
Prince Edward Island	North Shore, Prince Edward Island	1937	18.1	Beaches, dunes, marshes, sandstone cliffs	Migrating and nesting shorebirds
Terra Nova	East Coast Newfoundland	1957	396.5	Coniferous forest, wetlands, varied coastline	Moose, snowshoe hare, bald eagles, ospreys, ducks
Gros Morne	West Coast Newfoundland	1970	1,942.5	Coastal plain, tundra and rock barrens on interior plateau	Moose, snowshoe hare, caribou, terns, ptarmigan
Total			4,120.3		

Source: Taschereau, 1985[356]; Beardmore, 1985[361].

6.1.2 National Wildlife Areas

National wildlife areas (NWAs) are owned and managed by the Canadian Wildlife Service of Environment Canada. Habitat at these sites is protected by the Wildlife Area Regulations under the Canada Wildlife Act (1973). Limited recreational use is usually permitted and other activities can be authorized by issuance of a permit. Hunting, fishing, trapping, birdwatching, hiking, and berry-picking are generally allowed at most sites.

The NWA program was initiated in 1966, following tabling of a Wildlife Policy Statement in the House of Commons. Since that time, 8,194 ha of important wildlife habitat have been acquired at 12 sites in the Atlantic region (Table 28). Most areas are wetlands of considerable importance to waterfowl, with one site, Margaree Island, protecting habitat for colonial seabirds, and another, the Mary's Point section of the Shepody NWA, protecting significant habitat for migrating shorebirds. Both the Chignecto NWA and the Mary's Point section of the Shepody NWA are listed under an international convention as being wetlands of international importance.

TABLE 28
National Wildlife Areas in the Atlantic Region

Name	Location	Year Established	Area (km^2)	Major Habitats	Principal Wildlife
Portage Island	Miramichi Bay, NE New Brunswick	1979	440	Beach, wetlands, dune communities	Nesting piping plover, migrating waterfowl and shorebirds, nesting osprey
Portobello Creek	Saint John River, SE New Brunswick	NP	1,780	Floodplain, wetlands, and forest	Nesting and migrating waterfowl and songbirds, moose, and white-tailed deer
Shepody	Fundy Coast, SE New Brunswick	1980	980	Wetlands, intertidal flats, forest	Nesting and migrating waterfowl, nesting marshbirds, migrating shorebirds, muskrats
Tintamarre	Head of Cumberland Basin, SE New Brunswick	1977	1,990	Wetlands, forest	Nesting and migrating waterfowl, nesting marshbirds, muskrats

(cont'd)

TABLE 28 (cont'd)
National Wildlife Areas in the Atlantic Region

Name	Location	Year Established	Area (km²)	Major Habitats	Principal Wildlife
Cape Jourimain	Northumberland Strait, SE New Brunswick	1980	590	Saltmarsh, brackish marsh, oldfield uplands	Migrating waterfowl and shorebirds, nesting waterfowl
Chignecto	Cumberland Basin, NW Nova Scotia	1982	1,095	Saltmarsh, freshwater wetlands, forest, oldfield uplands	Nesting and migrating waterfowl, nesting marshbirds, migrating shorebirds and songbirds, muskrats
Wallace Bay	Northumberland Strait, NE Nova Scotia	1980	585	Freshwater wetlands, saltmarsh, forest	Nesting and migrating waterfowl, nesting marshbirds, muskrats, bald eagle
Margaree Island	Cape Breton, Nova Scotia	1982	54	Cliff face, forest, and heath upland	Nesting colonial birds
Boot Island	Minas Basin, Nova Scotia	1979	144	Saltmarsh, forest and grass upland, intertidal flats	Nesting colonial birds, migrating waterfowl and shorebirds
Port Joli	Atlantic Coast, SW Nova Scotia	NP	50	Intertidal flats, saltmarsh, forest	Wintering and migrating waterfowl
Port Hebert	Atlantic Coast, SW Nova Scotia	NP	42	Intertidal flats, saltmarsh, forest	Wintering and migrating waterfowl
Sand Pond	Southern Nova Scotia	1977	520	Freshwater wetlands, heath and forest uplands	Migrating waterfowl

NP = not proclaimed
Source: Environment Canada, CWS, 1985[362].

Management at each site is guided by a management plan prepared by CWS, with inputs and approval by a federal-provincial management committee. Ducks Unlimited Canada has been directly involved with management development of wetlands at six of the sites (Figure 32).

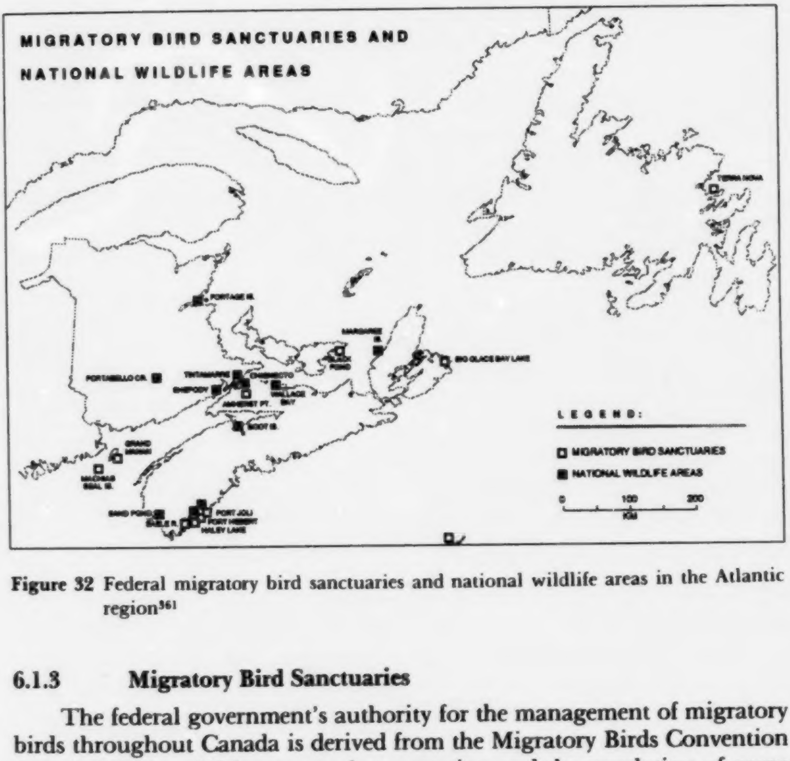

MIGRATORY BIRD SANCTUARIES AND
NATIONAL WILDLIFE AREAS
TERRA NOVA
PORTAGE IS.
MARGAREE IS.
BLACK POND
BIG GLACE BAY LAKE
PORTOBELLO CR.
TINTAMARRE
CHIGNECTO
SHEPODY
AMHERST PT.
WALLACE BAY
BOOT IS.
GRAND MANAN
MACHIAS SEAL IS.
SAND POND
SABLE R.
PORT JOLI
PORT HEBERT
HALEY LAKE
LEGEND:
MIGRATORY BIRD SANCTUARIES
NATIONAL WILDLIFE AREAS
0
100
200
KM

Figure 32 Federal migratory bird sanctuaries and national wildlife areas in the Atlantic region[361]

6.1.3 Migratory Bird Sanctuaries

The federal government's authority for the management of migratory birds throughout Canada is derived from the Migratory Birds Convention Act of 1917. In addition to species protection and the regulation of game bird harvest, the Act provides for the establishment of migratory bird sanctuaries.

Twelve sanctuaries are located in the Atlantic Region (Table 29), one each in Newfoundland and Prince Edward Island, two in New Brunswick, and eight in Nova Scotia. Sanctuaries are administered by the Canadian Wildlife Service, under the authority of the Migratory Bird Sanctuary Regulations. Generally, these regulations prohibit hunting or disturbing migratory birds, their nests or eggs, possessing any firearm or hunting device in a sanctuary, or allowing a dog or cat to run at large.

TABLE 29
Migratory Bird Sanctuaries in the Atlantic Region

Name	Location	Year Established	Area (km²)	Major Habitats	Principal Wildlife
Grand Manan	Grand Manan, New Brunswick	1931	250	Freshwater wetlands, barrier beach and dune	Migrating waterfowl
Machias Seal Island	Bay of Fundy	1944	10	Grassy upland, rocky shore	Nesting seabirds
Big Glace Bay Lake	Cape Breton, Nova Scotia	1939	240	Barrier beach and dune, saltwater lagoon	Nesting piping plover, migrating waterfowl
Kentville	Annapolis Valley, Nova Scotia	1939	200	Freshwater wetland	Nesting and migrating waterfowl
Port Joli	Atlantic Coast, SW Nova Scotia	1941	280	Intertidal flats, saltmarsh	Wintering and migrating waterfowl
Port Hebert	Atlantic Coast, SW Nova Scotia	1941	350	Intertidal flats, saltmarsh	Wintering and migrating waterfowl
Sable River	Atlantic Coast, SW Nova Scotia	1941	260	Intertidal flats, saltmarsh	Wintering and migrating waterfowl
Haley Lake	Atlantic Coast, SW Nova Scotia	1980	100	Freshwater lake	Migrating waterfowl, nesting great blue heron
Amherst Point	Cumberland Basin, NW Nova Scotia	1947	433	Freshwater wetlands, old-field and forest uplands	Nesting and migrating waterfowl, nesting marshbirds, muskrats
Sable Island	Atlantic Ocean, SE Mainland Nova Scotia	1977	2,350	Dune communities, beach wetlands	Nesting seabirds, migrating shorebirds and songbirds, Sable Island ponies, breeding gray seal

(cont'd)

TABLE 29 (cont'd)
Migratory Bird Sanctuaries in the Atlantic Region

Name	Location	Year Established	Area (km²)	Major Habitats	Principal Wildlife
Black Pond	Eastern Prince Edward Island	1936	130	Barrier beach and dune, brackish wetland	Migrating and nesting waterfowl
Terra Nova	Northeast Newfoundland	1967	870	Tidal inlets and flats	Migrating waterfowl and shorebirds

Source: Environment Canada, CWS, 1985[363].

The CWS conducts research activities at the Sable Island, Port Joli, Port Hebert, and Machias Seal Island sanctuaries, but habitat management activity is not undertaken since CWS does not own the land, (Amherst Point being an exception).

6.2 Ecological Reserves

An ecological reserve is a legally protected natural area where human influence is kept to a minimum. Natural change is allowed to proceed uninterrupted by humans to the furthest extent possible[358]. Ecological reserves are designated to preserve the diversity of plants and animals and to conserve natural areas for scientific research. The public, with few exceptions, is permitted to enter reserves, and although development is controlled, non-destructive recreational activities are appropriate on certain reserves[358].

The International Biological Programme (IBP) was the initial attempt to identify and protect ecological reserves in Canada. The ten-year program, funded by the National Research Council and terminated in 1974, was designed to pave the way for future advances in conservation and biological research. The objective of the Canadian IBP Conservation of Terrestrial Communities Subcommittee was to locate and protect representative examples of major Canadian ecosystems, and work for their preservation as ecological reserves. Lists of potential sites were compiled for 10 regions in Canada; these proposed sites were later examined by field teams and "check-sheeted" if they were found suitable to be considered for status as a protected ecological reserve. By 1974, 964 sites were formally identified across Canada, with 176 sites located in the Atlantic region. This process did not however, guarantee any site legal protection.

At the commencement of the IBP, there existed no ecological reserves legislation and no legal mechanisms for dealing with proposed sites. In 1971, British Columbia enacted the first ecological reserves legislation in Canada, and by 1972 had established 43 ecological reserves. At present, only P.E.I. and Ontario do not have an ecological reserves act. Each of the provincial ecological reserve acts has its unique set of regulations and criteria for selection of sites.

Since the end of the IBP, there has been little progress towards the protection of ecological reserves in the Atlantic region. With few exceptions, the majority of sites located outside national parks still lack adequate protection, a situation common to many other parts of Canada. Despite this, the prospects of achieving a national system of reserves is promising, due to an increase in public awareness, and the recent formation of the Canadian Council on Ecological Areas, to further the work initiated by the IBP[358].

6.3 Provincial and Private Preserves and Sanctuaries

Each of the Atlantic Provinces has its unique program of wildlife preserves, game sanctuaries and provincial parks. With few exceptions, provincially designated wildlife areas do not provide the degree of legislated protection offered by federal reserves or national parks. Protection at provincial wildlife preserves and game sanctuaries is usually limited to hunting or trapping restrictions, while provincial parks are geared for recreational activities. In spite of this, these designated areas offer some protection against development, particularly if they are on Crown Land. In addition, most provincial parks control access to designated areas and regulate adverse activities on sensitive beaches and dune systems.

Several non-governmental organizations are actively involved in the establishment of protected natural areas. The Nature Conservancy of Canada is a private, non-profit organization dedicated to preserving natural areas and increasing Canadians' awareness of their natural environment. A major activity of the Conservancy is the acquisition and transfer of land to public ownership, for maintenance and preservation as natural areas. The Conservancy has a representative in Nova Scotia and plans to increase its activities in the Atlantic region.

Ducks Unlimited (Canada) is a private, non-profit organization devoted to increasing North America's waterfowl by preserving, restoring and creating breeding habitats. Ducks Unlimited manages 51 projects in Atlantic Canada, covering 4,042 ha of Crown Land. The majority of projects are in Prince Edward Island and Nova Scotia. Lands are not kept in a natural state, but are actively managed, under agreement with the respective province, to increase wetland habitat. Management activities include the construction of access roads and dams, and the maintenance of water levels in reservoirs.

6.3.1 New Brunswick

New Brunswick's Ecological Reserves Act (1976) was the first such legislation to be proclaimed in the Atlantic region. Seven of 63 recommended sites (Figure 33) have been treated as legally designated reserves, and one site is pending[361]. These sites are currently awaiting publication of Orders-In-Council in the Royal Gazette before they are irrevocably set aside as protected areas. Many of the desirable provisions of an ecological reserves act are provided for in other provincial statutes. Inadequate funding is a problem with the New Brunswick ecological reserves program[358].

Several other statutes in New Brunswick offer limited protection of wildlife or natural areas. The Fish and Wildlife Act Regulations prohibit hunting and trapping in game management areas, game refuges and provincial parks. There is no additional regulation regarding development (or spraying) in wildlife management areas, especially on privately owned land.

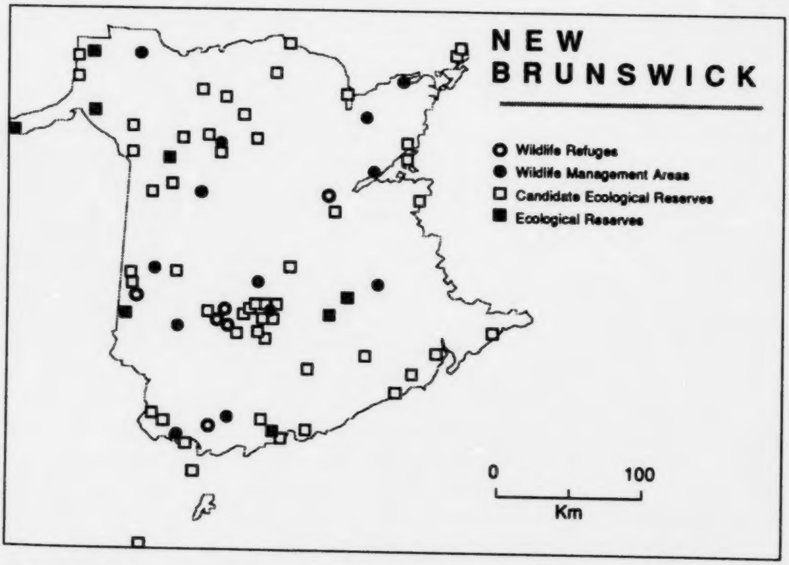


Figure 33 Ecological reserves, candidate ecological reserves, wildlife refuges and wildlife management areas in New Brunswick[361]

Under the New Brunswick Parks Act, provincial parks are developed primarily for recreational purposes. One notable exception is Mount Carleton Provincial Park, a 180 km² provincial park in northern New Brunswick. Mount Carleton is New Brunswick's only resource provincial park, with a comparatively small area developed for recreation. Hunting and aerial spraying are prohibited, but the harvesting of natural resources is permitted under controlled circumstances. Unlike national parks, most provincial parks in New Brunswick (and the other Atlantic Provinces) incorporate tourism, recreation, and economic benefits to the province as critical factors in their development.

Approximately 1,100 ha of Crown Land have been set aside as Park Reserve Land in New Brunswick. This results in some protection of sensitive areas from adverse development, but legislative backing or firm commitments to limit potentially destructive activities are limited. Under the Crown Lands and Forests Act, provisional emergency ecological reserves may be designated on Crown Land. With the exception of coastal areas within provincial parks, there is little legislative protection of beaches in New Brunswick. The Quarriable Substances Act does restrict the removal of sand and gravel from shore areas, but there is no protection of dune areas.

6.3.2 Nova Scotia

The Nova Scotia Special Places Protection Act (1981) has been proclaimed, yet few funds have been provided with which to administer the Act. Presently, only the 7 IBP sites located in the National parks are fully protected, although the Nova Scotia Department of Lands and Forests has identified IBP sites which may be threatened by forestry practices. The Nova Scotia Act provides for an advisory committee (which has met), but does not offer interim protection for potential reserves.

Nine provincial game sanctuaries and 12 wildlife management areas have been proclaimed under the provincial Lands and Forests Act (Figure 34). Game sanctuaries tend to be larger in area, and include regulations prohibiting hunting and trapping. Sanctuaries are established on both private and Crown Land for bird and wildlife protection. Sunnybrae and Waverley game sanctuaries have been established as natural areas where boy scouts maintain and preserve existing forests. Development, including construction, cutting and spraying, would be difficult to prohibit in sanctuaries designated on private land, although development can be controlled on Crown Land. There is, however, no legislative protection from adverse development on or near sanctuaries.

Wildlife management areas were established primarily in the late 1970s, after the realization that regulations should be based on the unique characteristics of each individual site. Therefore, activities such as hunting, fishing, boating, snowmobiling, bird watching or wildlife management may be allowed in some management areas. Conversely, access is tightly restricted at the Eastern Shore Islands wildlife management area, a highly sensitive seabird nesting site.

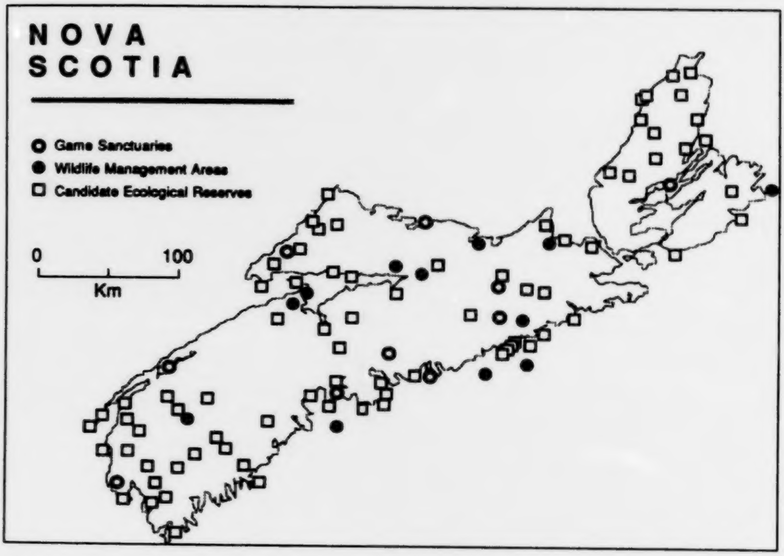


Figure 34 Candidate ecological reserves, game sanctuaries and wildlife management areas in Nova Scotia[361]

Approximately 100 provincial parks have been established on Nova Scotian Crown Land under the Provincial Parks Act. Provincial parks are designated as either campgrounds, picnic parks or beaches. There are no wildlife-oriented parks, but hunting is prohibited and deleterious development can be controlled. In addition, access may be temporarily controlled at ecologically sensitive sites. Three "wildlife parks" do exist, but they are not administered by the Provincial Parks Act, and most animals are held in captivity. The provincial parks system is being reviewed, and a new classification system may be adopted.

The Canadian Nature Federation (CNF), a national non-profit organization whose objective is the conservation of natural resources, has obtained a portion of Conrad's Island (by donation) in Halifax County. The CNF is discussing with the provincial government the joint management of the site as a protected natural area, with limited recreational or other development.

Beaches in Nova Scotia are protected under the Beaches Preservation and Protection Act. Under the Act, the removal of material from beaches is prohibited below the high water line. In addition, approximately 80 beaches are surveyed and designated under the Act, which offers some protection of the entire beach and dune system. The use of all-terrain vehicles (ATVs) are as yet unregulated, although legislation may be passed in the near future to control the movement of these vehicles in sensitive areas.

6.3.3 Prince Edward Island

With the exception of Prince Edward Island National Park and a CWS migratory bird sanctuary at Black Pond, there are few protected areas in P.E.I. Three provincial statutes incorporate regulations to protect natural areas. The Fish and Wildlife Act regulates four wildlife management areas[361]. Hunting is prohibited within their boundaries, but the regulations do not address habitat protection (Figure 35).

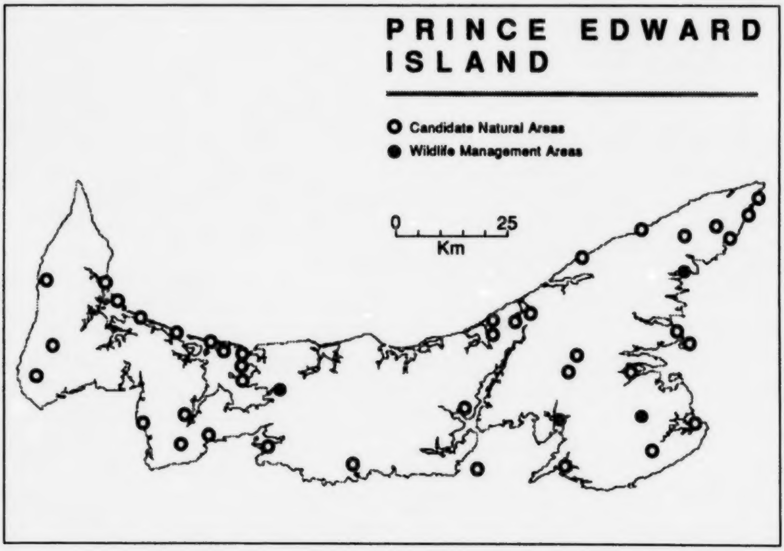


Figure 35 Candidate natural areas and wildlife management areas in Prince Edward Island[361]

Under the Planning Act, development can be prevented in designated areas until a management plan has been prepared. Similarly, the Recreation Development Act can keep adverse development from designated sensitive areas, such as beaches and dune systems. Provincial parks, including protected nature preserve parks, can also be created. The Recreation Development Act has in the past designated protected areas on both private and Crown Land. The provincial government has recently adopted the position that the Act should no longer be used to protect sites on private land, because land owners are not adequately compensated (or not compensated at all).

Ninety-eight percent of P.E.I. is under private ownership. Therefore, government protection of natural areas can only be accomplished by acquisition of land. Much of the land currently held by the Provincial Parks Branch was acquired between 1973 and 1978. The P.E.I. provincial parks system includes nature preserves in which controls required to protect the site can be instituted. Even though the land is owned by the provincial government, the site is not completely protected unless it is protected by legislation; only one site had been protected by legislation by 1984.

In general, beaches in P.E.I. are protected up to the high water mark, but dunes and marshes are not protected. Several beaches designated under the Recreation Development Act are better managed, with protected zones running approximately 46 metres inland. A restricted greenbelt area runs along the Morell River, which permits fishing and hunting, but tightly controls other development.

The Island Nature Trust, a local non-profit organization similar to the Nature Conservancy of Canada, leases 2 properties on the Island. Both properties will be jointly managed as natural areas by the Island Nature Trust and the provincial or local governments.

Prince Edward Island does not yet have an ecological reserves act. New legislation to acquire and protect natural areas is seen as a necessity for Prince Edward Island[365]. In 1982, the University of Prince Edward Island, at the request of the provincial government, selected 36 sites as candidate ecological reserves (Figure 35), but little has been accomplished to protect them[365].

6.3.4 Newfoundland

The Wilderness and Ecological Reserves Act (1980) of Newfoundland is cited as the best ecological reserves legislation in the Atlantic region[358], although some consider that access to sites there is too restricted. A proposal has been sent to the Newfoundland cabinet which will convert wilderness areas, game sanctuaries and provincial migratory bird sanctuaries to wilderness and ecological reserves, thus allowing for a greater degree of protection from adverse developmental pressure. Wilderness areas, including the Avalon wilderness area, must first be scrutinized by public review before they can be designated as reserves under the Act.

In 1983, 3% of the Island of Newfoundland and 1% of the entire province was protected as game sanctuaries or natural areas (Figure 36). Five seabird sanctuaries are protected as ecological reserves, 3 areas are protected as provisional ecological reserves and one site is a provisional wilderness reserve[358]. Mechanized access and land development are prohibited or strictly

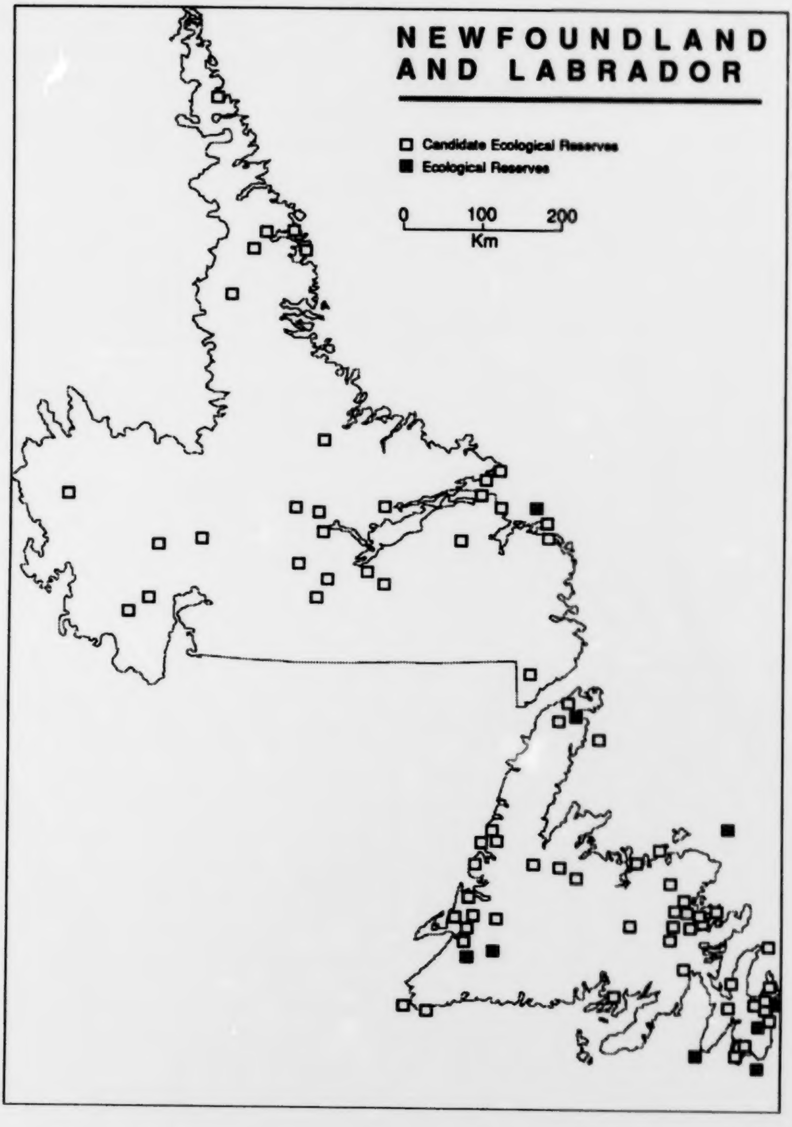

NEWFOUNDLAND AND LABRADOR
□ Candidate Ecological Reserves
■ Ecological Reserves
0 100 200
Km

Figure 36 Ecological reserves, and candidate ecological reserves in Newfoundland and Labrador[361]

controlled in these 9 reserves. However, reserves do not protect caribou in Labrador from a different problem — the effects of low flying aircraft on caribou migration. This has been the subject of recent concern by native people.

Potential reserves can be suggested by any private citizen or organization, at which time an advisory council evaluates the suitability of these potential sites and recommends whether or not they should be further evaluated and sent to public review.

The Avalon wilderness area is the only wilderness area designated under the Wildlife Act. With the exception of a small hydroelectric dam constructed before the area was designated as a reserve, development and all-terrain vehicles are prohibited, although hunting and fishing may be permitted. Newfoundland, unlike Prince Edward Island, does not have to acquire land from private owners, as most important wilderness areas are located on Crown Land.

The provincial parks system does not have a mandate to protect sensitive areas, but under the Provincial Parks Act, some natural features are preserved. There are no wilderness zones in provincial parks, as parks are generally arranged for recreational activities. The Provincial Parks Division of the Department of Culture, Recreation and Youth is currently attempting to define its roles in recreation and nature preservation[366].

Beaches within provincial parks are protected from quarrying and from developments which are not compatible with park objectives. Permits must be obtained to remove material from other beaches within the province.

Chapter 7

Developments in Environmental Management

Summary

Environmental impact assessment (EIA) has slowly evolved since the establishment of the federal Environmental Assessment and Review Process (EARP) in 1973. The latest step in this evolution was an Order-in-Council in 1984 which clarified the initial self-assessment stages of EARP. EIA processes tend to be consultative rather than regulatory; only the provincial process in Newfoundland has enforceable regulations. Less than 1% of the proposals referred for review in the region actually pass through the full process, which may include the completion of a comprehensive environmental impact statement and public hearings. Most projects are reviewed by government agencies and closed within 2 to 4 months. The accuracy of predicted impacts have generally not been formally assessed in this period, and therefore follow-up studies are required to accomplish this.

Offshore well-control problems and the loss of the Ocean Ranger rig have shown that offshore exploration is risky, and that accidental pollution discharges can result. Management activities, including rig inspections, the regulation of discharges from rigs, the development of contingency plans, and the identification of potentially vulnerable resources attempt to minimize potentially adverse environmental impacts. Similarly, oily discharges from ships are regulated under the Canada Shipping Act, which also provides for vessel traffic management systems which help to prevent discharges resulting from collisions and groundings. The Ocean Dumping Control Act has been developed to prevent the re-distribution of contaminants in dredge spoils and to ensure that contaminants dumped into the ocean result in minimal environmental damage. Most of these management mechanisms have resulted from international negotiations or conventions.

7.0 DEVELOPMENTS IN ENVIRONMENTAL MANAGEMENT

Public awareness of environmental issues in the early 1970s has influenced the evolution of environmental management in Canada. The formulation of policies and legislation has been stimulated by convincing scientific evidence revealing serious cases of environmental contamination, which could threaten human health or the functioning of natural ecosystems. Policies have, in turn, led to the growth of environmental impact assessment, integrated programs such as the Toxic Chemicals Management Program, and interdepartmental committees to review pesticide applications and ocean dumping.

Several federal-provincial agreements and accords now incorporate environmental protection with plans for economic growth. For example, environmental management for the offshore has developed rapidly, with several agencies responsible for reviewing potential adverse impacts from oil exploration, marine transportation and waste disposal. Many of the regulations used by these agencies have been influenced by international negotiations or conventions. Environmental management therefore, covers a wide spectrum of activities and developments; this chapter will attempt to examine briefly a few examples of such activities.

7.1 Environmental Impact Assessment (EIA)

The process called Environmental Impact Assessment (EIA) was developed in the early 1970s to identify potential environmental impacts resulting from the construction, operation and abandonment of proposed developments, and to incorporate environmental considerations at the planning stage. EIA in the Atlantic Provinces is carried out under provincial authority or by the federal government, under the Environmental Assessment and Review Process (EARP). Major projects may also be subject to a joint federal-provincial review.

7.1.1 Provincial EIA in the Atlantic Region

A brief review of provincial EIA processes for New Brunswick, Nova Scotia and Newfoundland is outlined below. Although there is no formal EIA process in Prince Edward Island, some environmental issues may be addressed under the Provincial Planning Act.

New Brunswick's policy on environmental assessment (1975) applies to developments proposed by provincial agencies, departments or provincial Crown Corporations, or other activities involving provincial funds or Crown Land. Under the policy, the New Brunswick Department of

Municipal Affairs & Environment (NBMAE) is responsible for environmental screening, developing project guidelines, reviewing Environmental Impact Statements (EIS) and holding public meetings[367]. Enabling legislation has been passed allowing NBMAE to formulate enforceable EIA regulations. This legislation is expected to obtain final proclamation after proposed regulations are drafted[368].

Nova Scotia derives the authority to require an EIA from the Environmental Protection Act (1977) and the Water Act (1973). The Nova Scotian process is not restricted to government-sponsored projects. Public hearings are not mandatory, although they have been conducted by the Nova Scotia Department of the Environment (NSDOE), provincial-federal review panels, or the Environmental Control Council (ECC). The ECC is an advisory council with members appointed from outside the provincial public service. If requested to comment on an EIA, the ECC may recommend that a project be permitted to proceed, with or without exceptions, or be refused[367].

Newfoundland's environmental assessment process is the most comprehensive in the Atlantic region. Participation in the EIA process is mandatory for any activity that may have an adverse environmental effect, but the Minister of the Environment determines whether or not an undertaking requires a formal EIS or an environmental preview report. A proponent who contravenes a provision of the Environmental Assessment Act (1980) or its regulations is liable to a fine and/or imprisonment. The EIA process in Newfoundland has several levels of review, depending on the significance of the project[367]. Public hearings or community meetings are held for those projects that generate concern in the communities affected; so far such projects have been the exception rather than the rule. By August 1984, 86 undertakings had been registered with the Minister of the Environment, and only 13 either required a full EIS or were still in progress[369].

Provincial (and federal) EIA processes tend to be consultative rather than regulatory. Impacts are noted, and mitigative measures are generally recommended, but not necessarily legally enforced. This system has resulted in some tangible environmental benefits. For example, control structures and improved tidal gates were constructed to mitigate adverse drainage of agricultural lands behind the Annapolis tidal barrage, and monitoring programs and on-site inspections may have been improved due to the EIA process in Newfoundland[369].

7.1.2 Federal Environmental Assessment and Review Process (EARP)

The federal government's Environmental Assessment and Review Process (EARP) was established by Cabinet in December 1973, amended in 1977 and formalized by an Order-in-Council in 1984. The EARP applies to proposals undertaken or sponsored by federal departments or agencies, for which federal funds are committed, or which involve federal property or areas of federal jurisdiction. The process is administered by the Federal Environmental Assessment Review Office (FEARO), which reports to the Minister of the Environment, but is an agency separate from Environment Canada.

The initial stage of the EARP is a self-assessment process; if an initiating department determines that a project may have significant environmental effects, the proposal must be referred to FEARO for review. This review may include an environmental impact statement (EIS), which is prepared by the project proponent, and includes an analysis of how the project could adversely affect the environment. The Environmental Assessment Panel (EA Panel) has the prime responsibility for developing guidelines for the EIS, reviewing the EIS, arranging public meetings and issuing final recommendations on the acceptability of the proposal. The implementation of EA Panel recommendations is not mandatory, but may be negotiated between the Minister of the Environment and the Ministers responsible for the project.

Seven proposals in the Atlantic region have been referred to FEARO for formal EA Panel reviews since 1974. A completed EA Panel review includes an EIS, public hearings and final recommendations. EA Panels have issued recommendations for 4 projects in the Atlantic region (Table 30). The Pt. Lepreau nuclear station and the Wreck Cove hydroelectric project are the only two which are currently operational; the Lower Churchill hydro project is not being pursued and the economic viability of the Venture gas development is currently being determined. To avoid duplication of EIA reviews, many EA Panels have a federal/provincial composition, allowing one activity to satisfy both review processes. Most EA Panel recommendations have addressed the need for monitoring programs and the filling of knowledge gaps (see Table 30).

7.1.3 Informal Environmental Assessments

In addition to formal EA Panel reviews, assessments of somewhat smaller projects such as the development of the Donkin-Morien coal mine, the Denison Mines potash development and the Annapolis tidal power project have been routinely carried out. These non-EA Panel assessments generally involve federal/provincial government review of documentation prepared by the proponent. There are no public hearings, and the environmental impact statements are similar, but smaller, than those prepared for panel projects. Construction and operational requirements are incorporated into a provincial permit. The provinces normally act as the lead agency, with federal input throughout the process[371].

TABLE 30
EARP Panel Projects in the Atlantic Region

Project	Date of Panel Report	Project Status	Major Panel Recommendations
Point Lepreau, N.B. Nuclear Generating Station	May, 1975	Operational Jan., 1983	More data on which to base fish protection facilities. Long term monitoring program to be initiated by NBMAE and government of Canada. Resulted in Pt. Lepreau Environmental Monitoring Program (PLEMP).
Wreck Cove, N.S. Hydroelectric Station	Aug., 1977	Operational March, 1978	No flooding of land in Cape Breton National Park. Management strategy to be developed for adjacent lands. Flow rate of Cheticamp River to be above level required to maintain population of Atlantic salmon.
Lower Churchill, Nfld. Hydroelectric Station	Dec., 1980	Withdrawn	Monitor fish populations, mercury levels in fish and erosion. Use existing transmission routes between Grand Falls and the Avalon Peninsula. Initiate studies of moose habitat. Compensate fishermen, fur trappers, and forest industry for financial losses.
Venture, N.S. Offshore Gas Development	Dec., 1983	No action at present; may be completed in the 1990s	Low toxicity drilling muds to be used. Contingency plans to be established for offshore and nearshore activities. Policy for treatment of oiled birds. Proposed emission and effluent levels to be reviewed by appropriate agencies. Pipeline routing studies to be initiated.
Point Lepreau II, N.B. Nuclear Generating Station	May, 1985	Project not being pursued at present	Derived emission limits be updated. Regulatory limit for discharge of radionuclides be reviewed. Annual decommissioning levy be scaled to permit higher contributions during first year of operation.
Hibernia Nfld. Offshore Oil Development	—	EIA in progress	
Fundy, N.S. Tidal Power Generation Project		Dormant	

Source: Environment Canada. EPS, 1985[370].

The majority of proposals from federal agencies never require an EIS or a formal review, but are routinely reviewed by Environment Canada and other agencies through a system of referrals. Individual referral systems include the Navigable Waters Protection Act (NWPA) referral for coastal developments, Department of Public Works (DPW) construction and maintenance projects, Small Crafts Harbours (SCH) land acquisitions and wharf extensions, Department of Regional Industrial Expansion (DRIE) funded proposals, and selected Atlantic Region Pesticide Advisory Council (ARPAC) referrals (Table 31). Routine reviews are also conducted by EPS under the Ocean Dumping Control Act (ODCA). Park's Canada screens proposals within national parks as part of their conservation mandate, and the Canadian Forestry Service screens several thousand small projects related to forestry activities, such as thinning, site preparations and stand conversions. As part of the Nova Scotia Forestry Resource Development Agreement (FRDA), herbicide applications are forwarded to EPS for review.

Many proposed projects, including several which fall under the NWPA, SCH, DPW and DRIE referrals above, are registered with the Regional Screening and Coordinating Committee (RSCC). The RSCC registers both EARP and non-EARP proposals, and serves to identify projects which require further review. Only 7 out of 2,724 proposals registered with the RSCC between 1974 and 1983 resulted in a completed or ongoing EA Panel review in the Atlantic region. Therefore over 99% of registered proposals are routinely reviewed and closed within 2-4 months. As in the case with formal reviews, environmental concerns and possible mitigating measures are identified and incorporated into the project. For example, effective waste treatment facilities have been constructed as a result of problems identified by DRIE referrals. Sensitive ecosystems and fish habitat, such as the Chezzetcook salt marsh in Nova Scotia, have been protected due to the mitigation of problems originally defined by referral through the NWPA (Table 31).

TABLE 31
Major Environmental Referrals in the Atlantic Region

Referral	Number		Agencies Involved in Referral	Proponent or Sponsoring Agency	Environmental Considerations
	1980	1983			
Ocean Dumping Control Act	120	142	EPS, DFO provinces	DPW, NHB, MOT	Controls dumping or burning of chemicals at sea. Controlled re-distribution of contaminants in dredge spoils. Some habitat protection and reduced conflict with fishery.
Navigable* Waters Protection Act	83	118	EPS, DFO, may include CFS, IWD, and provinces	MOT approves applications	Habitat protection and increased environmental awareness. MOT solely concerned with navigation; EPS coordinates environmental review and deals with proponent.

(Cont'd)

TABLE 31 (Cont'd)
Major Environmental Referrals in the Atlantic Region

Referral	Number		Agencies Involved in Referral	Proponent or Sponsoring Agency	Environmental Considerations
	1980	1983			
Department of Public Works	25	49	**EPS, DFO**	Several agencies, including DPW	Incorporates mitigating measures in construction. Advises on waste treatment facilities.
Small Craft Harbours	21	35	**DFO**, EPS	DFO	DFO has major role in environmental screening. Some protection of benthic habitat.
Atlantic Region Pesticides Advisory Committee	88**	102***	**EPS**, AES, CFS, CWS, IWD, AC	Provinces issue permits; AC issues federal research permits	Ensures that spray operations are conducted in an environmentally safe manner. Protects sensitive areas from pesticides and herbicides.
Forest**** Resource Development Agreement	—	60	**EPS**, AES, CFS, CWS, IWD, AC	NSDOE issues permits	Keeps herbicides away from sensitive ecosystems, watercourses and non-target areas.
Department of Regional Industrial Expansion	131	156	**EPS**, DFO and provinces	Industry proponents; DRIE provides funding	DRIE normally will not fund a project unless it obtains environmental approval. Significant reduction of local pollutant input.
Parks Canada	37*****	115	**PARKS**, may consult DFO	DPW, CWS, private industry	Protection of sensitive habitat within national parks and Parks Canada land.
Canadian Forestry Service	—	3334	**CFS** and provincial lands and forests departments	Private industry, provincial agencies	Protects habitat and watercourses. Ensures activities fall within forest management plans.

AES-Atmospheric Environment Service; AC-Agriculture Canada; CFS-Canadian Forestry Service; CWS-Canadian Wildlife Service; DFO-Department of Fisheries and Oceans; DPW-Department of Public Works; IWD-Inland Waters Directorate; MOT-Ministry of Transport; NHB-National Harbours Board; NSDOE-Nova Scotia Department of the Environment.
*Maritimes only. Does not include 250 referrals jointly considered by DFO and EPS in Newfoundland (1983).
**1981. ***207 referrals in 1984. ****Included in ARPAC total. *****1982.
Source: Environment Canada, 1982[372]; Eaton and Bradshaw, 1984[149]; C. Spencer EPS, pers. comm.[373]; W. Ernst EPS, pers. comm.[374]; P. Hennebury EPS, pers. comm.[375]; K. Kieley EPS, pers. comm.[376].

7.1.4 Follow-Up Studies

Follow-up studies compare actual project impacts with those which are predicted in an environmental impact assessment. They are necessary to determine the accuracy of EIA predictions or the degree of protection offered by mitigative measures. They can also improve the process of EIA by identifying limitations in the accuracy, interpretation, and presentation of data which results in inaccurate impact prediction. One study by the University of Aberdeen in Scotland noted that of 77 predictions (in 4 EISs), 44 were accurate and 33 were inaccurate. It was also observed that a number of impacts occurred which were not included in the statements[377]. Although agencies in the Atlantic region are careful to avoid this problem, with the exception of a preliminary study of selected non-panel projects by EPS, there has been little or no formal follow-up of completed projects in the Atlantic region.

7.2 Management of Toxic Chemicals

Regional pollution concerns from toxic chemicals have been thoroughly discussed in Chapter 3. This section will examine controls over toxic chemicals and measures for ensuring their safety to the environment and human health. Safety may be threatened when toxic chemicals are used improperly, are spilled accidentally, or where inadequate disposal methods are used. Even when they are used in a prescribed manner, toxic chemicals can still threaten the safety of the environment or human health because of unforeseen inputs due to a lack of knowledge, lack of proper or adequate testing, or from the cumulative impacts from more than one chemical. There is always some risk when toxic chemicals are used, and it is important to be able to assess this risk accurately and to minimize it through environmental controls.

One of the major challenges of government organizations has been the establishment of suitable systems for managing toxic chemicals. Such organizations have been instrumental in advocating better controls on the part of industry and federal and provincial agencies dealing with agriculture, transportation, and forestry. These controls form the basis of an improving management scheme.

Toxic chemicals have been defined in Chapter 3, but to reiterate, they include all chemicals which, even at low concentrations (in the ppm or ppb range), have an adverse effect on living organisms. They are often highly resistant to natural degradation, and many are bio-accumulative and concentrate in higher trophic levels. Some have been implicated in various diseases, including cancer, birth defects, chronic kidney ailments, neurological effects and liver damage. Toxic chemicals have also been found to cause long-term damage to wildlife and aquatic ecosystems by affecting feeding ability, reducing reproductive success, and altering the balance of species within ecosystems[147,378]. It is easy to understand the need to control these chemicals, and to assure society that the risk from these substances is minimized through suitable management.

7.2.1 Toxic Chemicals Control

7.2.1.1 Chemicals of Concern

Over 4 million chemicals are presently registered worldwide with about 70,000 in commercial use[379]. Priority listing of toxic chemicals is therefore important to define and manage those chemicals which could be of particular danger to the natural environment or to human safety. Environment Canada has developed a priority list of toxic chemicals in the Atlantic region in order to focus research, testing and assessment efforts[147]. Lists such as this have been generated on a national basis in Canada, the United States and other countries, and are usually updated frequently.

7.2.1.2 Control Mechanisms

Control over toxic chemicals is mainly exerted through legislation, with accompanying regulations and guidelines which define the products that are acceptable, their safe uses, and their acceptable levels in the environment. The federal and provincial legislation relevant to toxic chemicals control in the Atlantic region is listed in Table 32.

TABLE 32
Federal and Provincial Legislation Pertinent to the Control of Toxic Chemicals in the Atlantic Region

Name of Act	Agency(ies) Responsible	Date of Act and Revisions
Federal		
Environmental Contaminants Act	National Health & Welfare/Environment Canada	1981
Pest Control Products Act	Agriculture Canada	1968
Ocean Dumping Control Act	Environment Canada	1975
Oil and Gas Production and Conservation Act	Energy Mines & Resources	1968,'70
Fisheries Act	Fisheries & Oceans/Environment Canada	1970,'77
Radiation Emitting Devices Act	Atomic Energy Control Board	1970,'82
Clean Air Act	Environment Canada	1971,'81
Arctic Waters Pollution Prevention Act	Environment Canada	1970
Atomic Energy Control Act	Atomic Energy Control Board	1946,'76
Hazardous Products Act	Consumer & Corporate Affairs	1960,'83

(Cont'd)

TABLE 32 (Cont'd)
Federal and Provincial Legislation Pertinent to the Control of Toxic Chemicals in the Atlantic Region

Name of Act	Agency(ies) Responsible	Date of Act and Revisions
Transport of Dangerous Goods Act	Environment Canada/Transport Canada	1980
Food and Drugs Act	Health & Welfare Canada	1954
Pesticide Residue Compensation Act	Agriculture Canada	1970
Provincial		
P.E.I.		
Pesticides Control Act	P.E.I. Dept. of Agriculture	1984
Environmental Protection Act	P.E.I. Dept. of Community & Cultural Affairs	1975,'83
Dangerous Goods (Transport) Act	P.E.I. Dept. of Highways & Public Works	1981
Fish and Game Protection Act	P.E.I. Dept. of Community & Cultural Affairs	1974
N.S.		
Environmental Protection Act	N. S. Department of the Environment	1973,'77
Pest Control Products Act	N.S. Department of Agriculture	1970
Dangerous Goods Transportation Act	N.S. Department of Transportation	1982
Fisheries Act	N.S. Department of Fisheries	1977
N.B.		
Clean Environment Act	N.B. Department of Municipal Affairs & Environment	1973,'83
Pipeline Act	N.B. Department of Natural Resources	1976,'82
Pesticides Control Act	N.B. Department of Municipal Affairs & Environment	1973,'82
Oil and Natural Gas Act	N.B. Department of Natural Resources	1976,'83
Nfld.		
Pesticides Control Act	Nfld. Department of Environment	1970,'81
Waste Material Disposal Act	Nfld. Department of Environment	1973,'81

Source: Environment Canada. EPS, 1985[380].

In much of this legislation, toxic substances control is not the primary purpose (e.g. the Fisheries Act, the Oil and Gas Production and Conservation Act, and the Food and Drugs Act), but there is some legislation specifically designed to manage toxic substances. The federal Pest Control

Products Act, for example, deals exclusively with the registration, marketing, and utilization of pesticides. The Environmental Contaminants Act controls the production, commercial use, disposal, and sources of entry to the environment of substances deemed to be contaminants under the Act. The Clean Air Act and the Ocean Dumping Control Act seek to control the discharge of contaminants into specific media (the air and the oceans). Regardless of whether legislation is designed to deal with substances, products, or the protection of the environment, it is obvious that considerable governmental effort is being made to manage toxic substances.

In addition to legislative controls, toxic chemicals are dealt with in other ways including management programs, inventories, and public education. The Toxic Chemicals Management Program of Environment Canada is an example of one of the major efforts to integrate the huge task of controlling toxic substances and minimizing their adverse effects on the environment. This program has helped to address chemicals on a national basis, i.e. assess their hazard or risk, develop control strategies, evaluate impacts, and set priorities[381]. In this way a piece-meal approach to the management of toxic substances has been avoided. Although the program offers a comprehensive approach to the management of most toxic substances, there are instances where regional problems must be dealt with separately to effectively tackle unusual, or emergency situations such as PAH contamination at Sydney, N.S. (See section 2.2.1.6).

An important step in managing toxic chemicals is to determine the quantity and distribution of certain chemicals in use, in storage, or in waste disposal sites. In the Atlantic region, inventories are being conducted to determine the toxic waste generation potential of regional industries, the location of active and abandoned waste disposal sites, the location and quantity of PCBs both in use and in storage in the region, and the extent of pesticide use in the region. (See section 3.3). With this information, efforts are being directed toward cleaning up abandoned disposal sites where toxic wastes have been buried. Also, the production and use of toxic chemicals can be better controlled, as can the disposal of toxic wastes.

Efforts to increase the public awareness of toxic chemicals and their threat to human health and the environment is an important component of regional programs. Information brochures and fact sheets on toxic chemicals or hazardous wastes are produced by federal and provincial environmental and health agencies. These cover such topics as hazardous household wastes, pesticide safety, problems with PCBs, or disposal of hazardous waste. Others provide information to the public on specific legislation such as the Environmental Contaminants Act or the Ocean Dumping Control Act. Agencies in the region also conduct seminars, workshops or public lectures on toxic chemical management. For example, EPS Atlantic annually presents approximately 40 sessions on the proper use and disposal of toxic chemicals and 25 lectures on PCBs.

7.2.2 Environmental Screening of Chemical Substances

7.2.2.1 Industry and Government Testing

All chemical substances available for use in Canada are required to have undergone testing for possible health and environmental effects. Legislation such as the Federal Food and Drugs Act, the Pest Control Products Act, the Radiation Emitting Devices Act, the Hazardous Products Act, and the Environmental Contaminants Act is usually compatible with, or augmented by, similar provincial acts. The need for testing is clear from the fact that over 500 potentially toxic chemicals are introduced into the commercial market each year[379].

Canadian regulations place a large part of the onus for testing new chemicals on the manufacturer. In the case of pesticides, for example, the manufacturer must provide regulatory agencies with the chemical and physical characteristics of a substance. They must show that the product is practical, effective in controlling pests, and that its effect on non-target plants and animals is within acceptable environmental standards. Toxicity studies must be carried out, and satisfactory methods for residue analysis described. Most other types of chemicals and drugs undergo similar testing by industry prior to their release on the Canadian market[382].

A concerted effort is underway to bring about some international standards for chemicals management. For example, in the Organization for Economic Cooperation and Development (OECD) countries (which include Canada), there was a need for a collaborative approach to evaluate the health and environmental effects of the growing numbers of chemicals produced by the chemical industry in the 1970s. In response to this need, the World Health Organization (WHO), in 1980, established the International Program on Chemical Safety (IPCS), to evaluate the health and environmental effects of chemicals, and to develop methodologies and guidelines for testing and assessing risk[383,384].

Initial priorities for IPCS in 1981 were aimed at evaluating the safety of household products, pesticides, food additives and certain industrial chemicals. These priorities remain much the same with control agencies in Canada today. Manufacturers of these products have been forced to respond to recent pressures arising from occupational and environmental health concerns, with more definitive and complete assurances of the "safety" of their chemicals[385].

Testing of chemicals by government agencies is aimed at confirming or refining manufacturers' tests, or at examining the response of specific components of the environment such as fish, benthic invertebrates, pollinating insects, or songbirds. For example, the Department of Fisheries and Oceans conducts toxicity tests to determine the short and long term effects of certain chemicals on the health of fish populations. They also study the effects of chemicals on fish prey and on various aspects of fish habitat such as benthic plants and animals. Environment Canada studies the effects of pesticides on non-target organisms such as birds, mammals, stream invertebrates, and other forest insects. (See section 3.2). Testing is also done by Agriculture Canada, National Health and Welfare, Consumer and Corporate Affairs, and some provincial environment and health agencies[382,386].

7.2.2.2 Screening of Toxic Chemical Uses

In addition to the testing of toxic chemicals required at the time of manufacture or marketing, individual requests to apply chemicals commercially frequently undergo government screening. Although a chemical may be registered and approved for certain uses, the government can examine specific commercial uses of that chemical, or its use by other government agencies, to ensure that environmental hazards will be minimized. Various federal and provincial government screening procedures exist for this purpose.

Screening involves the careful assessment of all the known characteristics of a chemical: its solubility in water, toxicity, persistence in the environment, breakdown products, and effect on non-target species, to name a few. It also includes an assessment of how it is to be used. In the case of pesticides, for instance, this assessment includes the application methods to be used (fixed wing aircraft, helicopter, ground equipment, by hand); the area to be sprayed and why; the risk to non-target species and to humans, and the precautions which are to be taken. For industrial chemicals it is important to know how, where, and why they are to be used, and the precautions which must be taken to avoid spills or in the disposal of any wastes[385].

Most commercial applications of pesticides in the Atlantic Provinces require a permit from the appropriate provincial environment authorities who not only screen the application themselves, but usually refer it to other provincial agencies and to Environment Canada for their review[382]. The Atlantic Region Pesticides Advisory Committee (ARPAC) has been established amongst federal agencies in the region to provide advice to provincial and federal agencies on pesticide applications. ARPAC is unique to the Atlantic region and has influenced and improved the effectiveness of screening pesticide use in the region[387].

The management of the use of pesticides by federal agencies such as Canadian National Railway, Department of National Defence, and Transport Canada, is effectively carried out through the Federal

Interdepartmental Committee on Pesticides. This Committee screens projects and provides advice on their suitability directly to Cabinet.

Pesticide screening is generally more comprehensive than screening for other toxic chemicals, because pesticides are intended to be used in the environment. Nevertheless, environmental impact assessments conducted for major projects in the region include a close consideration of the chemicals used in industrial processes, chemicals present in plant effluents and emissions, toxic wastes, byproducts, and waste disposal methods. This process should provide effective screening, but not all projects receive such a thorough assessment, and even fewer projects receive a full formal Environmental Impact Assessment.

7.2.3 Hazardous Wastes

One of the consequences of the chemical industry and the large quantities of toxic substances produced and used in Canadian commerce, is a disposal problem. When toxic materials such as pesticides, certain industrial chemicals and chemical byproducts become obsolete or are no longer useful, they are defined as hazardous wastes, and must be dealt with in a very careful manner. The Sydney Tar Pond, the PCB spill in Kenora, Love Canal and the St. Clair River are recent examples of situations in which hazardous wastes were not dealt with adequately and where the health of the environment has been seriously threatened.

Hazardous wastes exhibit some of the characteristics of being toxic, explosive, corrosive, inflammable, strongly oxidizing (acids), poisonous, infectious, or radioactive. Some of them can present an immediate and destructive hazard to the environment and to human life, whereas others can pose a long-term, chronic threat to the environment if accidentally spilled or improperly disposed of. (See section 3.3). Many hazardous wastes are toxic and can seriously pollute the environment, whereas others, such as acids, pressurized gases, or explosives, are potentially destructive but pose little or no threat of pollution.

The public is protected from exposure to undue hazard from these substances through the enforcement of legislation such as the federal Dangerous Goods Act, the Atomic Energy Control Act, the Environmental Contaminants Act, and various provincial acts. An effort is also being made by environmental agencies to assist other government and non-government agencies and the public in dealing with hazardous wastes, by offering advice and training in hazardous waste disposal.

The past five years have demonstrated a significant trend of increasing regional concern over hazardous wastes, particularly on the part of provincial governments. Provincial laws have been strengthened, and programs to inventory hazardous waste sources and repositories, and to seek out abandoned dumpsites where toxic wastes may have been dumped, have been conducted jointly by the federal and provincial governments[388]. In addition, the provinces have environmental protection acts which include hazardous wastes controls. For example, Nova Scotia has a permit process under its Environmental Protection Act which provides for control over industries producing hazardous wastes. New Brunswick has a Pesticides Act which includes controls over the disposal of pesticides and pesticide containers. There are other such acts and regulations in the region (Table 32).

Among the benefits resulting from improved management of hazardous wastes is an effective federal/provincial program for providing advice on disposal methods to schools, universities, industry, government agencies and the public. Through this program, advice or assistance is provided in over 200 instances each year where chemicals, solvents, pesticides, industrial chemicals, explosives and other hazardous wastes must be disposed of[388]. In most cases a safe, effective, environmentally acceptable method of disposal is achieved.

Land disposal in municipal dumps or landfills has been the common practice for disposing of most hazardous wastes in the past. Until recently the management of these disposal sites was haphazard, with no clear jurisdiction among provincial, municipal or other authorities, and with uncontrolled use of dumpsites by public and private operators. The location of the dumps, and the type and quantity of waste, was frequently left unrecorded[83]. Some of the problems associated with these dumps are contamination of groundwater, surface water and domestic well water, which in some cases has presented a potential threat to human health and safety[389]. Improved management of hazardous wastes and their disposal has helped to correct problems at some of the active sites, and has led to cleanup programs at other sites such as Camp Gagetown, Chatham, and the Sydney Tar Pond. (See section 3.3).

7.3 Management of the Marine Environment

The federal government has the primary jurisdiction over marine environmental quality and pollution control. This mandate is distributed amongst four major federal departments. The Departments of the Environment (DOE) and of Fisheries and Oceans (DFO) share responsibilities under the Fisheries and Ocean Dumping Control Acts. These Acts include the application of effluent regulations and guidelines, habitat protection and the control of ocean dumping. (See also Chapter 2). The Ministry of Transport (MOT) is responsible for the control of pollution from vessels, while the Department of Energy, Mines and Resources (EMR) manages activities related to offshore oil and gas exploration (with input from other departments).

7.3.1 Offshore Oil and Gas Development

Exploration for oil and gas off the Canadian east coast began in the Sable Island area in 1959 and on the Grand Banks in 1964[390]. Since then, approximately 200 wells have been drilled, and although numerous small pockets of oil and gas have been discovered, only the Venture and Hibernia discoveries in 1979 are considered to be of commercial interest (Figure 37). To put this in perspective however, over 250 exploration wells were drilled in the North Sea before the first commercial field was discovered[390].

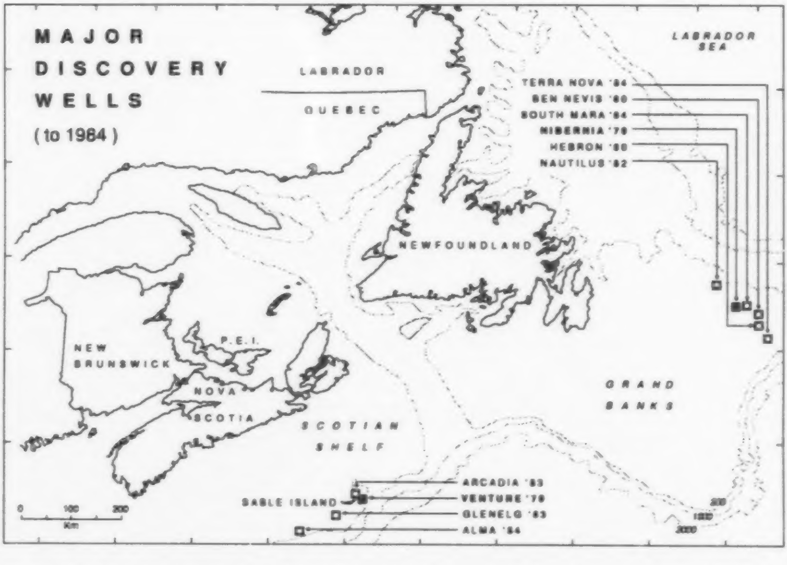

MAJOR
DISCOVERY
WELLS
(to 1984)
LABRADOR
QUEBEC
LABRADOR SEA
TERRA NOVA '84
BEN NEVIS '80
SOUTH MARA '84
HIBERNIA '79
HEBRON '80
NAUTILUS '82
NEWFOUNDLAND
NEW BRUNSWICK
P.E.I.
NOVA SCOTIA
SCOTIAN SHELF
GRAND BANKS
SABLE ISLAND
ARCADIA '83
VENTURE '79
GLENELG '83
ALMA '84
0
100
200
Km
200
1000
2000

Figure 37 Major offshore oil and gas discoveries along the Atlantic east coast (to 1984)[398]

7.3.1.1 Environmental Risks

Major oil spills and well blowouts are serious environmental concerns off the east coast of Canada. Risk assessments for these events off Atlantic Canada have not been conducted, although several accidents or near accidents have been reported during the past 5 years. These include the loss of the "Ocean Ranger" rig, two well control problems on the Scotian Shelf, the emergency landings of two helicopters at sea, two incidents where ships nearly collided with rigs, and numerous occasions on which rigs have been forced to move away from the path of icebergs and sea ice[391].

Severe weather conditions can increase the risk of a major accident. Winds in excess of 90 kts. and waves greater than 17 m initiated a chain of events which led to the loss of the "Ocean Ranger" rig and her crew in 1982[392]. Drilling muds, additives, and 1,179 tonnes of diesel and other hydrocarbons were released during the incident, much of which was believed to have been dispersed by wave action. Major oil discharges from a blowout could have resulted if the rig had not detached itself from the well at the onset of the severe weather conditions. The storm which initiated the incident, while severe, generated winds and waves which were below maximum predicted intensities for the Grand Banks (Table 33).

TABLE 33
100 Year Wind Speeds and Wave Heights off the Atlantic Coast of Canada

Region	100 Year Wind Speeds (knots)	100 Year Wave Heights (metres)
Labrador Shelf	100-105	29-32
Grand Banks	110	28-31
Scotian Shelf	105	26
Georges Bank	110-115	24-26

Source: Mortsch *et al.*, 1985[393]; Neu, 1982[394].

The Uniacke G-72 gas well blowout off Sable Island.

Two well control problems occurred on the Scotian Shelf, partially as a result of high geological pressure zones encountered during drilling. The West Venture well, while not resulting in a blowout, took nine months to control, while the Uniacke G-72 well released an estimated 1.9 to 2.4 million cubic metres of gas and 23.4 cubic metres (150 barrels) of condensate per day during an 11 day blowout. Laboratory research indicated that the condensate was highly toxic to marine biota, although most slicks dissipated within 5 km of the rig. Some oiled birds were noted, although total mortality was difficult to determine due to the offshore nature of the spill[395].

Accident risk is also increased in ice infested waters. Pack ice limits the drilling season on the Labrador Shelf to 3 months per year, and while drilling may proceed year round on the Grand Banks, pack ice and icebergs may appear in some years before mid-winter. For example, twice in 1983 pack ice and icebergs forced rigs working the Grand Banks to move to safer locations[396], since conventional rigs cannot withstand the impact of even small icebergs. Pipelines would also be susceptible to rupture from icebergs, especially if they were constructed on the Grand Banks (icebergs are rare on the Scotian Shelf).

7.3.1.2 Offshore Management

The present Canadian management regime for offshore oil and gas resulted from increased national jurisdiction over the resources of the Continental Shelf; the need to maximize financial benefits; the occurrence of major polluting disasters in Canada and abroad, and the negotiation of federal-provincial accords and government energy policies. Management of offshore development and control mechanisms for environmental protection are outlined below.

The Canada Oil and Gas Lands Administration (COGLA), formed in 1981 under the direction of the Ministers of Energy, Mines and Resources and Indian and Northern Affairs, is responsible for the management of oil and gas exploration and development on federal lands off the east coast of Canada (not including the Bay of Fundy). The Environmental Protection Branch (of COGLA) is responsible for ensuring that projects are environmentally safe and acceptable to coastal provinces. COGLA also ensures that offshore hydrocarbon activities are considered within the Federal Environmental Assessment and Review Process, so that measures to prevent or reduce environmental impacts can be incorporated early in the project. In this respect COGLA has acted as initiator for both the Venture and the Hibernia Environmental Impact Assessments.

In Newfoundland, the Canada-Newfoundland Offshore Petroleum Board appointed under the Atlantic Accord negotiated between the Governments of Canada and Newfoundland, will assume much of

COGLA's responsibilities for the Grand Banks and Labrador Sea. As of early 1985, the administrative structure for environmental protection had yet to be determined.

The Oil and Gas Production and Conservation Act and the Canada Oil and Gas Act form the major legislative base for offshore exploration and development for most of the Canadian offshore. Legislation implementing the Atlantic Accord will replace both Acts for the Grand Banks and Labrador Shelf. Under the Oil and Gas Drilling Regulations, operators (oil companies) are required to submit contingency plans for environmental and other emergencies. Minimum equipment standards must be met to prevent most accidental and/or polluting incidents from occurring. Operational spills and pollution from other sources, such as drilling muds, biocides and process water, are controlled by rig inspections carried out by COGLA with some advice from Environment Canada. Environment Canada's participation in evaluation and enforcement is supported by Section 33 of the Fisheries Act[397].

The probability of a major oil spill or gas blowout is increased as offshore activity increases. Technology is not advanced enough to contain and clean up a large offshore spill, particularly in ice infested waters or adverse weather conditions. Contingency planning, or the formulation of an action plan to follow in the event of mishaps or catastrophe, may reduce the likelihood of significant environmental impacts from a spill, by identifying resources at risk and outlining cleanup and response procedures. These are required to be prepared by offshore operators for each drilling program. Contingency plans include background environmental data, oil spill models and estimates of the type and quantity of pollutants discharged. Oil containment, cleanup and communication exercises are regularly practiced by industry and government agencies in order to be prepared to respond to emergencies[398].

EPS has produced a series of 5 Environmental atlases, containing biological, oceanographic, meteorological and socio-economic information for much of the east coast. These atlases are used as tools in planning and responding to oil spills. Shoreline geomorphology and sensitivity maps have also been prepared by the major east coast operators. Some of this data has been compiled in a computer data base for rapid access in case of an emergency, and the system is being refined to extend its applicability.

7.3.2 Marine Transportation

More oil enters the marine environment than any other toxic contaminant[399]. Marine transportation is responsible for 46% of the worldwide input of oil into the oceans. Approximately 71% of this input is from the chronic discharge of oil from vessel operations[128]. An estimated 1.4 million litres (1,200 tonnes) of oil are discharged per year from bilges and tank cleaning operations off Atlantic Canada. Most of these discharges are scattered along major tanker and shipping routes on the Scotian Shelf and Cabot Strait[266]. These discharges are a threat to seabird populations whose reproductive patterns are accustomed to low natural mortalities and which are already under stress from hunting and drowning in gill nets[400]. (See also Chapter 2).

TABLE 34
Largest Ship Spills in the Atlantic Region (1974-1984)

Name of Vessel	Quantity Spilled	Type Spilled	When Spilled	Where Spilled	Cause	Effects
Golden Robin	151 tonnes	Bunker	Sept. 14/74	Dalhousie, N.B.	Grounding	Extensive contamination of shoreline. Loss of salt marsh vegetation.
M. V. Carita	540 tonnes	Bunker Diesel Lube oil	Dec. 20/75	Cape North, N.S.	Grounding	Little impact due to stormy weather conditions and cliff-dominated shoreline.
Imperial Bedford	147 tonnes	Diesel	Jan. 21/77	Charlottetown Harbour, P.E.I.	Drain plug fell out of tank	Little environmental impact, as most oil recovered.
Kurdistan	7,965 tonnes	Bunker	Mar. 15/79	Cabot Strait, N.S.	Vessel split in two while in heavy ice	Extensive contamination of Newfoundland and Nova Scotia coastline. Seabird mortality (25,000). Some oiling of clam flats and fishing nets.
Imperial Acadia	257 tonnes	Diesel	June 26/82	Port aux Basques, Nfld.	Grounding	Shoreline oiling within small cove. Effects diminished by evaporation of diesel due to warm temperatures.

Source: Environment Canada. EPS, 1984[402].

Major east coast incidents such as the "Kurdistan" spill (Table 34) have dumped more oil in the sea than is annually discharged from tanker operations in waters off the Atlantic region. The Canadian Coast Guard has identified two offshore areas with a relatively high accident risk — the approaches to the Cabot Strait along the Scotian Shelf (Figure 38), and the great circle route between the United States and Europe (particularly where other shipping lanes are crossed)[266]. Both of these areas are located close to productive fishing grounds and large concentrations of birds and marine mammals. Busy ports such as Saint John and Halifax also have a high potential risk of a spill resulting from a shipping accident.

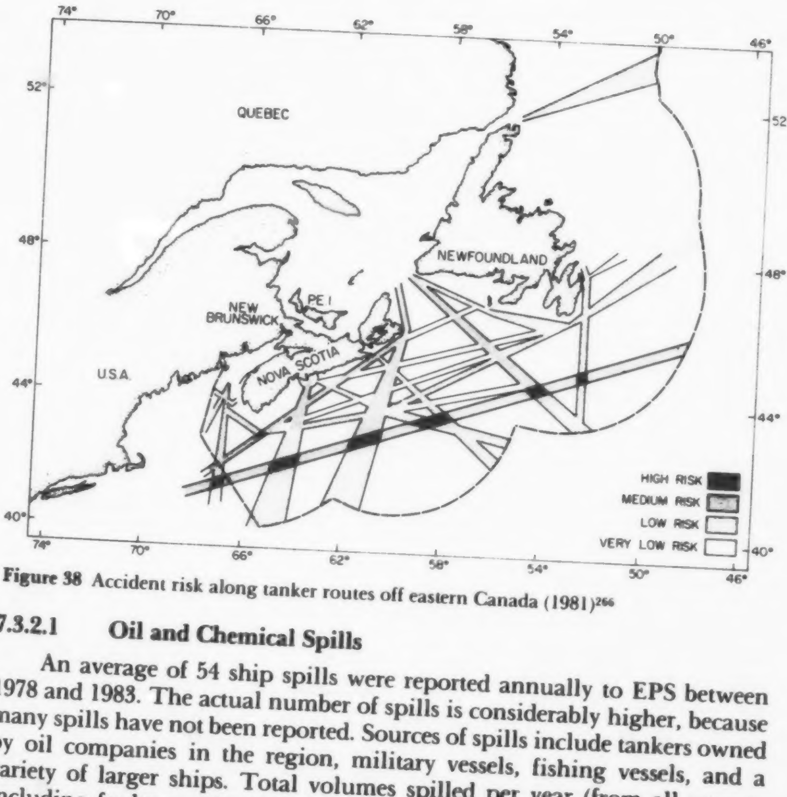


Figure 38 Accident risk along tanker routes off eastern Canada (1981)[266]

7.3.2.1 Oil and Chemical Spills

An average of 54 ship spills were reported annually to EPS between 1978 and 1983. The actual number of spills is considerably higher, because many spills have not been reported. Sources of spills include tankers owned by oil companies in the region, military vessels, fishing vessels, and a variety of larger ships. Total volumes spilled per year (from all sources including faulty terminal and storage operations) range from 915 tonnes in 1981 to over 10,100 tonnes in 1979[401,402]. These annual totals fluctuate due to the influence of large incidents such as the 8,000 tonne "Kurdistan" spill in 1979.

Toxic chemicals such as sulphuric acid and phosphorus are also routinely transported by ship from eastern Canadian ports. Fortunately, chemical spills (excluding oil) are rare off the Canadian east coast. Only 7 chemical spills were recorded in a 1981-1983 EPS spill inventory. Only one spill was recorded offshore, the other spills were caused by leaking containers or faulty dockside operations. (See section 3.4).

Environmental impacts from ship spills vary, depending on the location of the spill, the weather conditions present, and the quantity and type of material spilled[403]. For example, the 151 tonne "Golden Robin" spill resulted in more widespread shoreline contamination and environmental effects than the much larger "Carita" spill (Table 34). The latter incident occurred during rough seas at an exposed shoreline which quickly dissipated the spill, while the "Golden Robin" spill occurred in calmer weather near sensitive salt marshes. The "Kurdistan" spill not only was very large, but consisted of highly complex bunker oil. The persistence of this oil was increased by ice cover, thus allowing it to contaminate large areas of shoreline and kill thousands of seabirds during the spring and summer of 1979[404].

Many oil and chemical spills can be prevented through training, vessel inspections, construction and equipment standards, and traffic regulations and guidelines which prevent collisions and groundings. Regulations are also in place to reduce operational discharges of oil. Some of these mechanisms are outlined below.

7.3.2.2 The Canada Shipping Act

Part XX of the Canada Shipping Act deals specifically with pollution from ships. The Act is directed at preventing discharges of oil from ships and at providing compensation for pollution damage and cleanup where a spill has occurred. The Fisheries Act and the Ocean Dumping Control Act also have some authority for controlling ship generated pollution.

The Canada Shipping Act prohibits the discharge of oil in the territorial sea or the fisheries zone to a distance of 200 nautical miles. Any person or any ship discharging a pollutant or failing to give factual information in contravention of regulations under the Act is liable to a fine of up to $100,000. Canada is considering becoming a signatory to the International Convention for the Prevention of Pollution from Ships and its 1978 Protocol. This will allow discharges with an oil concentration not exceeding 15 ppm within waters of Canadian jurisdiction. This less stringent requirement is, however, a more generally accepted international standard.

The Canada Shipping Act helps to prevent environmental damage by reducing the number of potentially polluting marine casualties. The Eastern Canada Traffic Zone (ECAREG) and the more comprehensive Vessel Traffic Management Systems (VTMS) in busier east coast ports, were designed in the mid-1970s to protect the marine environment by preventing marine accidents through a traffic monitoring system (which includes monitoring vessels on radar)[405]. For example, traffic regulators at the Saint John VTMS prevented a cargo vessel from grounding in Saint John Harbour, thereby preventing a possible bunker C spill. In addition, had a traffic system been in operation in Chedabucto Bay in 1970, regulators might have been able to warn the Master of the "Arrow" that he was approaching a rocky shoal, thus preventing a major tanker spill[406].

Major disasters such as the "Arrow" (Chedabucto Bay, N.S.), "Torrey Canyon" (United Kingdom), and "Amoco Cadiz" (France) spills have incurred claims and cleanup costs of $4.5 million, $36 million and $3 billion respectively[406]. A Maritime Pollution Claims Fund has been created under the Canada Shipping Act to reimburse cleanup expenses and compensate for losses caused by spills from unidentified vessels (primarily compensation for damaged fishing gear), although access to this Fund appears to be difficult.

7.3.2.3 Surveillance

Effective surveillance and enforcement can be deterents to illegal discharges of oil from ships. Aerial surveillance of ships in the Great Lakes has caused the number of pollution sightings to drop steadily over the past few years, suggesting that it has had a positive effect[266]. The Department of National Defence (DND) routinely conducts military and fisheries aerial surveillance and notifies the Canadian Coast Guard of any polluting vessels spotted within Canadian waters. Approximately 1 polluting vessel is sighted per week off the east coast[266]. These sightings have resulted in only 11 fines (totalling $90,500) between 1977 and 1983, because most vessels sighted were not moving inbound to a Canadian port, and had to be prosecuted by their home country. Most incidents occurred at the approaches to the Cabot Strait, the Scotian Shelf south of Halifax, and on the great circle route between the United States and Europe[407].

7.3.3 Ocean Dumping Control

The sea has been used as a dump for waste materials for centuries with the thought that its depth and vastness could absorb all waste materials without any adverse effects. The error of this thinking became more obvious as greater pressures were placed on the oceans to receive waste of growing complexity and toxicity, and as technology advanced in the area of chemical analysis (contaminants detection) and ecological impact assessment. By the mid 1960s and early 1970s it was realized that toxic substances from contaminated material discarded as waste in the oceans ended up in the food web, either threatening human health or the health of marine species. Dumped contaminants, such as nuclear wastes, cadmium, PCB and mercury, were found to have become widespread in the water column or in sediments, where their potential availability to biota were of concern.

The input of contaminants to the marine environment from ocean dumping is substantial, although it is by no means a major source. In one year on the Atlantic coast of the U.S., approximately 49.7 million tonnes of materials are disposed of by ocean dumping. These included industrial waste, sewage sludge, construction and demolition debris and dredged material. Even with large quantities such as this, it is obvious that only a small portion of the contaminants entering the oceans comes from direct dumping. Most contaminants enter via industrial effluents, runoff, atmospheric deposition, municipal discharges and riverine input. Nevertheless, the world powers drafted the London Dumping Convention in 1972 and adopted measures designed to protect the world's oceans from being deliberately used as a dumpsite for waste. Canada became a signatory to the Convention and as a result brought into force the Canadian Ocean Dumping Control Act (ODCA) in 1975.

The ODCA, by means of a permit system, provides strong legislative control of the dumping of wastes into the ocean. Environment Canada is charged with the administration of the Act and the issuing of permits, while DFO shares in the assessment of dumpsites, and ocean dumping research, and is responsible for coordination on an international front. The Act is limited to intentional dumping from Canadian ships or ships leaving Canadian ports (including any kind of floating vessel or aircraft), but does not include dumping from land. The types of material covered by the Act include: dredged material; chemical wastes or other waste materials; fish plant waste or offal; items such as abandoned ships or aircraft; any waste material placed on sea ice, and any material taken to sea for disposal by incineration.

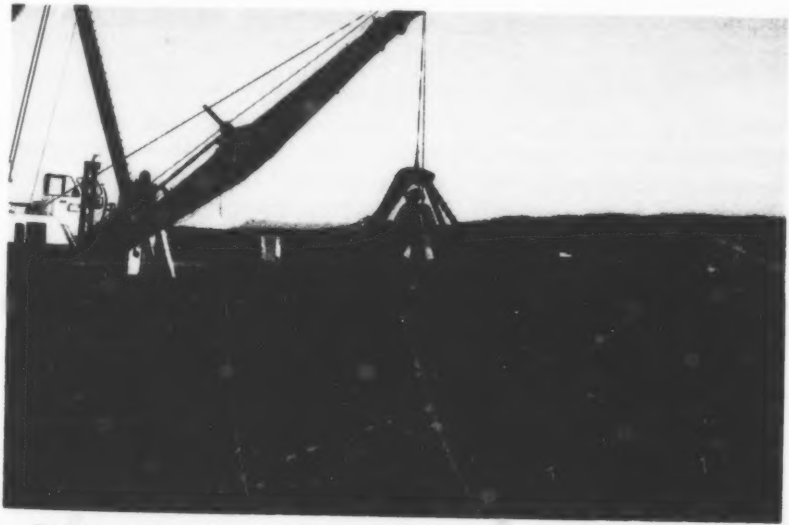
Over the period 1977 to 1985 approximately 1,900 permits have been issued in Canada for ocean dumping. Of these, about 90% were for dredged material while the remaining 10% were for ship disposals, chemical waste, offal, disposal of garbage or waste on ice, etc. (Table 35)[408]. Because of the large number of small harbours which require dredging in the Atlantic Provinces, this region accounts for over 60% of the total number of ocean dumping permits issued in Canada, although the volume of material dumped (mostly dredged material) is only 25% to 30% of the national total[149].

TABLE 35
Summary of Permits Issued and Quantities of Dredged Material Dumped in the Atlantic Region (1975-1983)

Date	Total Number of Permits	Number of Dredged Material Permits	Non-dredged Material Permits	Volumes of Dredged Material (x $10^6 m^3$)
1977	99	89	10	1.8
1978	129	116	13	8.2
1979	126	116	10	6.0
1980	111	100	11	4.4
1981	99	91	8	7.5
1982	66	57	9	7.8
1983	77	61	16	2.8

Source: Environment Canada, 1984[408].

Much of the material dumped in the Atlantic region (approximately 90%) is clean dredged material, but there are situations where contaminated dredged materials are involved. In some of these cases it has been necessary to develop alternative methods of disposal. For example, contaminated dredged materials from Lockeport Harbour and Halifax Harbour in Nova Scotia were trucked away to land disposal sites, rather than being dumped into the ocean. Also at Dalhousie, N.B., 120,000 cubic metres of contaminated material were dredged and placed in an enclosed area cut off from exposure to the marine environment, thus preventing widespread contamination which had resulted from open water disposal. In the Miramichi River, contaminated dredged material was dumped in specially selected areas where impacts would be minimal, and then covered with clean material. In this case a major monitoring program was carried out to detect any adverse effects from this operation on the local lobster and shellfish fisheries, and on the migration of salmon and other anadramous species through the estuary.



Dredging and ocean dumping is controlled under the Ocean Dumping Control Act.

Protection of the marine environment is provided by the ODCA permit process, since this allows restrictions to be placed on the concentration of specific contaminants in material to be dumped, and also allows control over when and how the material is dumped. If the material or the dumpsite is unsuitable, a permit can be denied. For example, discarded ships must be cleared of oil or other contaminants and dumped in deep water where they will not interfere with fishing operations. Dredged material or chemical wastes must not exceed set levels for mercury, cadmium, certain organochlorines (such as PCB, DDT), petroleum residues, persistent plastics, and radioactive materials. They also may not contain excessive amounts of contaminants such as arsenic, lead, copper, zinc, nickel, chromium, and pesticides other than the organochlorines above[156]. The procedure set up to review applications for dumping considers a large number of factors and other environmental constraints before a permit to dump is issued, thus ensuring a maximum level of protection. Full consideration is given to effects on fisheries, oceanographic features, benthic communities, wildlife and recreational pursuits.

The benefits of these procedures are obvious, both in terms of protecting sensitive marine habitat from physical burial by dumped material, and in controlling the input of undesirable toxic chemicals. The presence of the Act itself also probably has a preventative influence on would-be ocean dumpers, causing them to seriously consider other options. Despite the positive features of the ODCA however, there are serious gaps in the understanding of the impacts of ocean dumping on the marine environment, and it is a fact that very few applications for ocean dumping permits in the Atlantic region have been rejected.

With growing demands to use the ocean as a disposal ground for nuclear wastes and other toxic chemicals, enforcement of ocean dumping controls will become crucial. The U.S. National Advisory Committee on Oceans and Atmosphere (NACOA) suggests that ocean dumping will become a more important waste management option, in comparison to land, deep-well, and atmospheric disposal alternatives. If Canada follows a similar path, the coastal provinces could be affected through shipping and handling of toxic wastes in transit for dumping. Also, coastal regions may ultimately suffer as a result of negative impacts from such dumping in the marine environment, unless ocean dumping controls are carefully maintained and research into the environmental effects of ocean dumping continue.

The ODCA, and participation in the London Dumping Convention, allow Canada to participate in an international or global effort to manage waste disposal in the oceans. This includes the development of standards, the discussion of suitable disposal criteria for toxic and hazardous wastes, and participation in, and benefit from, cooperative research on the impacts of ocean dumping on the marine environment.

Chapter 8
Trends in Environmental Research

Summary

Acid rain research is both a regional and a national priority, and has expanded considerably since 1979. Research objectives include precipitation modelling, aquatic and terrestrial effects and the development of new combustion technologies designed to reduce emissions from coal-fired power plants. Water quality research has changed its focus from nutrients and BOD monitoring to trend assessments and toxic chemicals. A major step forward has been to move from studying direct lethal effects to examining the sub-lethal effects of toxic constituents. The movement of chemicals to groundwater supplies from dumpsites, industrial effluents, leaking underground storage tanks and pesticide application is a recent research concern. Marine quality research, particularly the impact and effects of hydrocarbons and other contaminants in coastal and offshore waters, continues to be a major emphasis at several of the world-class research facilities located in the region.

8.0 TRENDS IN ENVIRONMENTAL RESEARCH

Research on environmental issues is necessary to develop policies, regulations and guidelines to protect the environment and to ensure that environmental quality is maintained. Research is also required to develop the information base on which to formulate environmentally sound development plans for future industrial developments in the Atlantic region.

Both government and industry fund environmental research. In the 1982/83 fiscal year, $110 million was spent by DOE and other federal agencies for research across Canada. Acid rain research was given a substantial boost in the fall of 1980, when $41 million was committed for a 4 year expansion of research in Ontario, Quebec and the Atlantic region[409]. The $10 million Environmental Studies Revolving Fund was set up in 1981, which, through oil industry funding, has initiated several offshore hydrocarbon research projects in frontier areas, including the east coast offshore.

Examples and trends in environmental research are highlighted below for air pollution, water quality, the marine environment and toxic substances.

8.1 Air Pollution

Acid rain has been identified as a priority issue by the Government of Canada, and is considered the number one environmental concern by many Atlantic Canadians. Air pollution was, until the late 1970s, thought to be a problem of only local magnitude. In 1979, the preliminary report of the joint Canada — U.S. working group studying the long range transportation of air pollution (LRTAP) identified acidic precipitation as the "problem of greatest common concern at the present time"[296].

A large part of the research effort on acid rain in the Atlantic region is centred at Kejimkujik national park, N.S. The Kejimkujik Calibrated Lakes Catchment Program is an interdisciplinary effort, including research in precipitation modelling, effects on aquatic and terrestrial ecosystems and the determination of what levels of sulphur depositions result in adverse effects. Future acid rain research will likely attempt to determine the linkages between emissions, the acidity of precipitation and the acidity of the receiving environment. More research is necessary to determine the magnitude and mechanisms of the atmospheric transport of other toxic contaminants such as PCBs, pesticides, metals and petroleum hydrocarbons[128,409,144].

Other research associated with air pollution control in the Atlantic region is devoted to assessing new combustion technologies to reduce SO_2 and NO_x emissions from power plants, and investigating the impact of total suspended particulates and PAH emissions from woodfuel combustion.

8.2 Inland Water Quality

Water quality research has changed its focus from wide regional surveys, and nutrient and BOD monitoring in the 1960s and early 1970s to trend assessments and toxic contaminants. In 1978, the federal agency responsible for freshwater quality, the Inland Waters Directorate of DOE, shifted emphasis to concentrate on Canada — United States boundary waters and specific problem areas. The International Saint John, and St. Croix River Basin Studies are two ongoing boundary water studies whose goals are to define and meet specific water quality objectives.

Research will expand on non-point source pollutant loads from urban and agricultural runoff. A recent concern is the impact of acidic runoff from mineralized geological zones in Nova Scotia and New Brunswick. The relationship between acidic runoff, acid rain, the buffering capacity of groundwater and the reduced pH of rivers in southwestern Nova Scotia will also be investigated. Innovations in water conservation and management may also be necessary in the near future.

Monitoring is a critical component of environmental protection.

Although groundwater use in the Atlantic region is significant, little research has been completed on the fate, movement and persistence of pesticides and other organic contaminants in groundwater systems. Recent groundwater research included work on the pesticide aldicarb in P.E.I. groundwater, and the development of an arsenic removal filter. Groundwater will be a higher priority in future, with planned studies on salt-water intrusion, water use patterns, groundwater-surface water interrelationships, and flow systems in fracture zones[410].

8.3 Marine Environmental Quality

Marine environmental research is important to a coastal area such as the Atlantic region, and fortunately the region has a strong research community. Local universities, government agencies, smaller research institutes, and the Bedford Institute of Oceanography have made the

Halifax-Dartmouth area one of the 3 largest centres for research in the marine sciences in North America[411]. Other important marine research institutes are located in St. John's, Nfld., and St. Andrews, N.B.

The bioavailability of toxic organic substances has been the focus of recent research. The concentration of contaminants in water, air and sediments was actively monitored in the 1970s, but the fraction which would be available to organisms in a toxic form was largely unknown. Recent work has examined the uptake of PCB, PAH, DDT, cadmium and mercury by plankton and marine invertebrates, and the accumulation of contaminants by the food chain. Conversely, the cleansing or depuration of contaminants from marine organisms, particularly shellfish, is being studied. This latter research may also result in the increased marketability of contaminated shellfish through a depuration process.

The toxicity of oil and water-based drilling muds, and new technologies to combat oil spills are other important research areas in the Atlantic region. Advances have been made since 1975 in understanding the quantity, fate, movement and behaviour of spilled oil in the marine environment. Unfortunate incidents such as the "Arrow", "Kurdistan" and "Argo Merchant" oil spills have provided for the accumulation of field data to support laboratory studies, although more controlled, small scale field studies are still required[129]. A major step forward has been to move from direct lethal effects to more subtle sub-lethal adverse impacts. Advances have recently been made in our understanding of the effect of oil on benthic communities, but little is known about impacts on fish stocks and other pelagic organisms[129]. More data is also required to predict potential impacts from offshore development and to predict long-term population impacts.

8.4 Toxic Chemicals

A growing list of over 50,000 chemicals are in use in North America. The persistence, toxic effects, and routes of exposure of these chemicals is a continuous research priority. Emphasis has recently been placed on groundwater contamination from toxic chemicals and on atmospheric transport and deposition. A Department of the Environment/National Health & Welfare priority list currently identifies PCBs, chlorofluorocarbons, chlorobenzenes, phthalic acid esters, paraffins, chloroethanes, chloroethylenes, chloromethanes and organotins as national priority chemicals. However, substances such as cadmium, lead, mercury, arsenic, and polycyclic aromatic hydrocarbons are also of concern in specific locations throughout the region. The chemicals on the national priority list are identified for further research, in order to [illegible] on those which may warrant future regulation.

Pesticide research is very active in the Atlantic region. The fate and ecological effects of the forestry insecticides fenitrothion and aminocarb were the subject of numerous studies between 1976 and 1984. Included in present research is the evaluation and testing of safer spray formulations. Recently some of the focus has shifted to the large variety of agricultural insecticides, fungicides and herbicides applied throughout the region. There are still many information gaps to be filled, including long-term ecological and health effects of pesticide use, and the relative importance of exposure through food, absorption or inhalation. Pesticide drift has been studied for various chemicals and methods of application, but more research is needed to determine the relative importance of different pathways pesticides can take in spreading through the environment.

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